SCIENTIFIC AMERICAN
No. SUPPLEMENT 354

Scientific American Supplement. Vol. XIV., No. 354.
Scientific American, established 1845.

NEW YORK, OCTOBER 14, 1882.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

ELECTRIC LIGHTING BY BATTERIES.

CAN batteries charged with liquids be employed for electric lighting on a considerable scale without the expense involved in their use being out of all proportion to the result obtained? All the experiments made up to the present have given a negative response, but this has not prevented inventors from continuing their researches in this direction, and in the ardor of their convictions these *savants* have persuaded capitalists and financiers to make the necessary sacrifice in order to give their ideas a practical shape, and to bring them within the domain of accomplished facts. Considered entirely from a special point of view, the installation which we are about to describe presents an interest quite unique, and is a witness of a confidence which we are far from sharing in. However, we shall content ourselves at present with simply describing what has been done, and what is about to be done, reserving for a future date, when the cost of the system is known, an expression of the economic advantages and the disadvantages of the installation.

The Comptoir d'Escompte is a magnificent building in Paris, and in which the able architect, M. Corroyer, has taken advantage of the most recent advances made in science and industry. The records deposited in the Comptoir represent a considerable sum, and in the interest of their preservation, in order to diminish as much as possible the chances of fire, the suppression of gas lighting and the introduction of electric lighting was decided upon. By way of precaution it was determined not to employ a steam-engine in the base of the establishment, and the installation of this machine in the neighborhood presented insurmountable difficulties. It was necessary, therefore, to have recourse to batteries, and in order to avoid obnoxious fumes it was decided to employ the bichromate form. The pattern settled on by MM. Grenet and Jarriant does not differ in principle from the aerated form devised by M. Grenet in 1857, and constructed at this date with the object of applying it to chirurgical operations. At the Comptoir d'Escompte bichromate of soda was substituted for bichromate of potash, the cost of the latter being the higher of the two; aeration is effected mechanically instead of by a hand bellows; and all the arrangements of detail are combined in order to facilitate the daily use of such a large number of elements, for the complete installation does not include less than 60 batteries of 48 elements each, or 2,880 elements in all. One half of the batteries is already in use, the other half is also actually set up ready to be brought into use in October next. When fully at work the electric lighting of the Comptoir d'Escompte will represent an electric power of 50 horses.

We will now describe the installation. Each battery is composed of 48 zinc-carbon elements (with a single liquid) joined up in series. The solution is made of 75 kilogrammes of bichromate of soda and of 150 kilogrammes of sulphuric acid for each cubic meter of liquid. Each element is formed of a square ebonite cell provided with an overflow pipe to draw off the solution. The positive pole is formed by four rectangular plates of carbon arranged parallel to the sides of the cell; the negative pole consists of a little cup of ebonite containing mercury, in the center of which is fixed a metallic stalk. Around this stalk are arranged four or six zinc rods plunged into the mercury; this insures good contact and also a perfect amalgamation of the zincs; the cylinders of zinc are held vertically around the stalk by means of India-rubber rings. The carbons are fixed in the cells, while all the zincs are suspended across, which allows of their being withdrawn or plunged into the solution; the active surface of the zinc can thus be varied, and the internal resistance adjusted according to the current required. The connection of a carbon to a zinc is effected by means of a little metallic tube fixed to the carbon and half filled with mercury, into which is plunged a stalk fixed to the zinc; this allows of the vertical withdrawal of the zincs without interrupting the connection of the elements. The solution of bichromate of soda is prepared beforehand in large quantities at the workshop, and is pumped into large reservoirs at the top of the building. From there it is brought below to each battery by a special pipe service—very well arranged, although rather complicated—provided with taps of ebonite and pipes of India-rubber.

The fresh liquid can be used three times over. The first time it flows at the rate of 20 liters per hour, and through the battery of 48 elements; the second time at the rate of 30 liters, and the third time at the rate of 40 liters. By adding a little of the fresh liquid it can be used over for a fourth time. When thus used it drains through at the rate of 60 liters per hour per battery; after which the liquid goes through a process of regeneration. MM. Jarriant and Grenet profess to be in possession of an economical process for the regeneration of the liquids, a process which allows of the separation of the chrome and the zinc from the alkaline sulphate, by a new method. This process, which is no longer a secret, being patented by MM. Jarriant and Grenet, appears to us to be decidedly complicated. The following is a rapid enumeration of the manipulations necessary to effect the regeneration of the products:

1st. The saturation of the excess of sulphuric acid by carbonate of lime; the precipitation of the sulphate of lime, of the oxide of chrome, and of the carbonate of zinc. The liquor which remains contains alkaline sulphate.

2d. The decantation, concentration, and crystallization of the alkaline sulphate.

3d. The separation of the carbonate of zinc from the oxide of chrome, and of the sulphate of lime, by a certain quantity of sulphuric acid, which is calculated exactly to

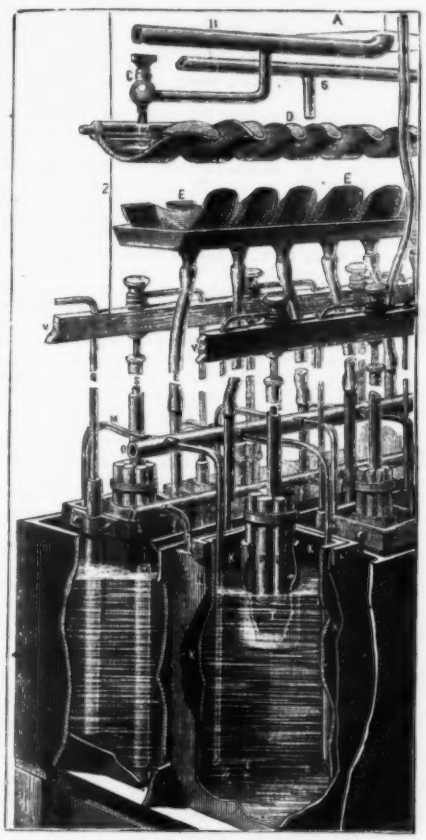


FIG. 1.—DETAILS OF THE ELEMENTS OF ONE OF JARRIANT & GRENET'S BICHROMATE OF SODA APPARATUS.

ELECTRIC LIGHT BATTERIES AT THE COMPTOIR D'ESCOMPTE, PARIS.

transform the carbonate of zinc into sulphate of zinc. The liquor which remains contains sulphate of zinc, which is concentrated after decantation for crystallization.

4th. The desiccation, pulverization, and mixing of the sulphate of lime and oxide of chrome with quicklime and the alkaline carbonate.

5th. The calcination of the above mixture on the hearth of a reverberatory furnace and the extraction of the chromate by *known processes*.

We see that the generation of the products is by no means a simple operation, involving as it does five processes, not counting the *known processes*, and the carriage of the liquids from the Comptoir to the workshop, and from the workshop to the Comptoir.

Let us now return to the batteries. We can see that the overflow pipe serves to maintain the level constant in the elements in proportion as they are filled with fresh liquid; this circulation of the liquid serves in a certain degree to keep the current constant, a constancy still more preserved by an aeration produced in each element by means of two tubes of ebonite, which plunge into the bottom of the liquid. In order to obtain the air necessary for the aeration without special expense, advantage is taken of the compressed air used for the pneumatic transmission of messages between the various offices of the Comptoir.

Under ordinary conditions, the volume of air furnished to each battery is about three cubic meters per hour, under a pressure equal to the height of the liquid in the elements, or about 15 to 20 centimeters of water.

The installation is completed by a supply of water for cleaning the elements, and a double sink for the discharge; one of the sinks is employed for remixing the liquid for charging the batteries, the other holds the water for washing the elements and conducts it into the sewers.

The negative pole of each battery is connected to a common lead wire; the positive pole is joined to a commutator which has fifty bars. The feeding apparatus is also connected to a common negative lead wire, and the positive poles are attached to the same commutator; the batteries occupy the horizontal bars, and the lighting apparatus the vertical ones. We only require, therefore, to place a peg where two given bands meet in order to establish communication between a battery of a given number and a given series of lighting apparatus. Either the Swan incandescent lamps or the arc lamps of Siemens, Gravier, etc., are used as occasion requires. Each battery of 48 elements in series has an electromotive force of 82 volts, and can give as much as 24 ampères on a short circuit. We see by these figures that a single battery is sufficient to feed a number of incandescent lamps or a voltaic arc with 10 carbons of 10 millimeters, which works very well with 10 ampères. We can besides group several batteries in tension or in quantity as occasion may require, in order to supply more powerful arc light or a larger number of incandescent lamps; it is with this object and also for the purpose of having a few reserve batteries that the commutator has only 50 positions, although the complete installation should have 60 batteries.

The employment of a distinct wire for each lamp, and of a wire for each battery, the negative being in common, constitutes rather a serious expense at the first installation, but it has the advantage of rendering the apparatus, lamps, and batteries absolutely independent of one another. In case of accident it is easy to localize it and repair it, and thus the accident is never very serious. An indicating table arranged opposite the Swiss commutator enables the lighting of any given hall to be regulated from a distance; the workman charged with the superintendence of it knows which are the right batteries to work, and has only to place the pegs. Besides, the lamps can be lit or extinguished at will by commutators arranged in the hall, when communication is established between a battery and a given circuit by means of the Swiss commutator.

Such is the principle of MM. Jarriant and Grenet's installation of bichromate batteries for the lighting by electricity of the Comptoir.

The future will throw some light on the economic view of the question, concerning which we have as yet very vague ideas. This point will decide the future of the installation; but whatever fate may be reserved for it, it was no less interesting to describe the general outline of an installation in which for the first time for industrial purposes and practical application an electrical energy of fifty horse power has been produced by the employment of liquid batteries.

We take the foregoing from the *Electrical Review*. We also present two engravings—the two largest—from *La Lumière Electrique*.

THE ELECTRIC LIGHTING OF THE COMPTOIR D'ESCOMPTE (PARIS).

The application of the electric light that we are about to make known to our readers is one of much greater importance than has ever before been attempted with the use of hydro-electric piles as the source of electricity. The problem of lighting the Comptoir d'Escompte by electricity involved some very peculiar conditions. For instance, the installation of a steam motor in the cellars near the Registry of Deeds presented serious dangers; and putting an engine in a neighboring building was none the less impossible, because of the high price of rents in so central a quarter, and of administrative difficulties relating to the putting up of the conductors necessary for connecting the electric works with the banking house, the place of consumption.

The able architect of the establishment, Mr. Corroyer, surmounted the difficulties by employing hydro-electric piles, and this is the new and original point of the installation. The entire service will include sixty single liquid bichromate of soda piles, although only a portion of these is at present in use. This is, in substance, an industrial application, on a large scale, of the pile invented by Mr. Grenet in 1857, and combined under a new and practical form by Messrs. Grenet and Jarriant. The batteries are arranged at the top of the building near the roof, and are disposed with as much regularity as the blunt corners and mansard roofing of the edifices will permit of. Fig. 1 shows the details of one battery, and Fig. 2 a series of batteries in line. See first and third pages of this number.

Each battery consists of forty-eight elements, disposed in two juxtaposed lines of twenty-four elements, in rectangular wooden troughs. Each element consists of an ebonite receptacle containing the liquid, a solution of thirty-eight kilogrammes of bichromate of soda and seventy-five kilogrammes of sulphuric acid per cubic meter of liquid. The bichromate of soda here replaces bichromate of potash, which costs much more.

The positive pole of each element consists of four plates of carbon placed in a rectangular trough and held together by a lead cap. To this latter there are also fixed two small ebonite tubes which extend to the bottom of the trough and serve for the insufflation of air. The carbons are stationary and always dip entirely into the liquid, whose level is regulated in each element by an overflow pipe, *f* (Fig. 1). The negative pole of each element is formed of a circular receptacle of hard rubber, in whose center there is fixed a copper rod, *s*, protected by an insulating tube. The lower part of the rod dips into the mercury contained in the receptacle. It is on the base of this receptacle that rest the zinc cylinders, U U, held against the rod, *s*, by rubber bands. The mercury insures of a proper contact and an always perfect amalgamation of the zinc until it is completely used up.

Generally, six zinc cylinders of one centimeter in diameter are put into each element. All the zincs are suspended from two horizontal beams which are capable of being lifted by means of a system of pulleys and gearings balanced by counterpoises (Fig. 2). The pile may thus be easily set in action or *vice versa* by immersing or lifting the zincs, and the active surface dipping in the liquid may be regulated, etc. In order that the communications between the zinc of one element and the carbon of the following may remain permanent despite the displacements of the zincs, there is fixed to each of them a square-shaped metallic rod whose vertical arm enters a tube, P, which contains mercury and is connected with the carbon of the succeeding element (Fig. 1). The zincs can thus be lifted or lowered without the communication being broken between the forty-eight elements, all mounted *for tension* in each battery.

The solution of bichromate of soda, which is prepared in advance at the works, is brought in special wagons and forced by means of a pump into large reservoirs at the top of the building. From thence a special system of pipes leads it over each of the batteries. The liquid is drawn through an earthen cock, C, into a series of small ebonite pans, D, shaped something like the chapeau of a *gendarme*. As soon as these ebonite vessels contain a certain quantity of liquid (a liter, for instance), they tip over on their one axis in common and empty into a second series of receptacles, E, from whence the liquid flows through rubber tubes into each element below, while the overflow pipe carries off an equal quantity of liquid drawn up to the upper part of each element into leaders corresponding to other reservoirs placed in the lower story. The flow of the liquid is regulated by the cock, C, according to the nature of the liquid, the current to be produced, etc. The new liquid is capable of being used three times; the first time, it is caused to flow at the rate of about twenty liters per hour and per battery; the second time at the rate of thirty liters; and the third time, at the rate of forty liters. On adding a little new liquid afterward, the solution may be made to serve a fourth time, by causing sixty liters of it to pass per hour and per battery of forty-eight elements. After this, the liquid is practically used up and is sent to the works to be made over again. This process of regeneration, in regard to which we have no very precise information, permits, according to Messrs. Jarriant and Grenet, making over again the active elements by separating the chrome and zinc from the alkaline sulphate through one of the cheapest of processes. On this particular point we reserve our opinion. The washing and cleaning of the elements is performed by means of a tubing for water parallel with that that leads the bichromate of soda. The water that has been used for the washing afterward flows off into the sewer through a series of pipes laid along the flooring.

A final system of tubing is that designed for the insufflation of air. Here, to avoid expense and a special installation, advantage has been taken of the distribution of air designed to work the pneumatic tubes that do service for the different offices of the Comptoir. The gas motor and the pump that it actuates have, then, a double role to perform; for the air under pressure serves at once for the pneumatic dispatches and the insufflation of the elements.

The air reaches each battery through a horizontal tube, O, from whence starts a series of small tubes, *o*, which dip into the ebonite boxes to the number of two tubes per element. The quantity of air forced in is regulated by a cock. Under such circumstances, by properly proportioning the flow of liquid and the escape of air to the electric work to be effected, there is contained a perfectly constant current—one of the most satisfactory conditions for the regularity of the light. The electro-motive power of each battery formed of forty-eight elements is about eighty-two volts, and, on a short circuit, the intensity of the current is twenty-four ampères. Messrs. Jarriant and Grenet estimate that each battery in full activity will yield an electric energy equivalent to a one and half horse power, or one hundred and twelve kilogrammes per second.

In the arrangement adopted at the Comptoir d'Escompte, the operation of each battery is independent of that of all the rest. All the extreme zincs are connected with one wire in common, which forms the negative. Each of the positive poles is attached to a large Swiss commutator of fifty directions. To this latter are also connected the fifty conductors corresponding to the arc lamps or to the series of incandescent ones arranged in the different parts of the building. All the communications can thus be quickly established, and there may be ascertained at a single glance, without possibility of error, what number of piles are doing duty and what number of lamps are in operation at a given moment. Owing to the common negative and to the Swiss commutator, there is never any need of maneuvering but a single key for setting up a communication between a given battery and the focus that it is to supply. Accidents are thus quickly located, substitutions of lamps and piles are effected with the greatest facility, and the accident attended to in a few instants without ineffectual researches and without having to go about the matter blindly.

The various electric lamps employed offer no peculiarity. According to the nature of the apartments to be lighted and the special wants to be satisfied, a mixed lighting has been adopted through Siemens or Gravier voltaic arc lamps or Swan's incandescent ones. Such an eclecticism has the advantage that it permits of making a choice after comparative experiments, and of adopting those arrangements that shall have given the best results after a test of some duration.

Such is, in its prominent features, the installation of electric lighting at the Comptoir d'Escompte, and a portion of which is already in operation, and the whole of which will be complete in October.

As may be conceived, electric works on this system can only be established on a large scale to make it of interest to put in so multiple a system of piping: (1) for the active liquid; (2) for the water for washing; (3) for the insufflation of air; (4) channels for the reception of the used up liquid, and (5) channels for the reception of water that has been used for cleaning, without counting the small mechanical installation necessary for insufflation and for forcing liquids into the reservoirs, the cartage of liquids to and from the works, and, finally without counting the somewhat complex question of regenerating the products. So, while admiring the happy arrangement of the system, and the ingenious devices invented by Messrs. Jarriant and Grenet in this installation, which is as unique from its nature as from its importance, we feel that we must, as regards its economical point of view, withhold our opinion. It will be necessary to wait for precise figures relative to the total cost of the installation and to the price of keeping it in repair, while taking into account all those multiple factors that it is proper to reckon in, in order to know whether the production of a fifty horse power electric energy by bichromate of soda hydro-electric piles is not economical, but only of a price comparable with that of a direct production by a fifty horse power steam engine and dynamo electric machines.

In reality, the most economical solution of the question, in our opinion, would be the use of a small ten horse power engine to charge accumulators continuously. The latter could then be grouped and discharged according to requirements. Thus would be done away with all cartage except that of coal for the motor, and any process of regeneration, which, however excellent it be, still leaves some doubt in our mind.—*E. Hospitalier, in La Nature.*

HAND DYNAMO MACHINES.

In a paper read before the British Association, by W. H. Preece, F.R.S., he said:

When in Paris, I saw an extremely compact and useful dynamo machine. There are a good many in this room who have occasionally to appear before the public as lecturers, and there are also many who are engaged in instruction. Most of us require at times, in our laboratory and rooms, some convenient mode of producing a very powerful current. The only machine available for us is the small magnetic machine of the Gramme type, where a ring is rotating in the field of powerful permanent magnets. In this particular instrument, however, the field is produced as it is produced in ordinary dynamo machines, such as used in the production of electric light. Owing to the peculiar construction of this chapel, I have been unable to fix the instrument (the maker of which I may say is Baron M. De Meritens) so that all can see it, but I have it in the hall, and I will work it so as to show you some of its effects. The armature of the machine is of the Paccinotti type—made of a series of flat plates serrated. The ring is furnished with projections 16 in number, through which 16 wires, one for each, are brought to the commutator, which is similar to that used in the Gramme machine. The ring rotates in the field of an electro-magnet just as is done in the Gramme and Siemens. I have two men who will work the machine, and from the currents produced, which are brought near by means of two conductors, I hope to form a small electric light. The electromotive force when working at full speed is 70 volts, the resistance of the field magnet is four ohms, and the resistance of the armature is four ohms. The connection is such that either the field magnet can be put in as a shunt, or as a series in the ordinary way. Four men working it will produce a capital electric light, and one man a capital Swan or Edison light. Two men should, I think, be able to keep three lamps going. The price is only £15 without the mechanical construction, and the whole thing complete is one of the most convenient that could be used for very many purposes.

The first experiment with the machine was a total failure, owing apparently, as Mr. Preece explained, to some short-circuiting, which he hoped they would be able to remedy.

Mr. Taylor said that when last in Paris he had looked about for some machine of this kind that would give a good current, and could be turned by man power, and he had found only two machines that would fulfill these conditions. He had obtained one—a machine by Giaraud—and from what he had seen of it since he did not think that De Meritens machine, as described by Mr. Preece, was any better. His Giaraud would feed a Swan lamp well with one man turning it. It was a magneto, not a dynamo. It had eight electro-magnets constituting the armature, made and unmade by passing between the poles sixteen steel magnets. It would give an arc light very well as long as there was some one to watch the distance of the carbons. It was sufficiently powerful to melt fine iron wire. The price was 1,000 francs. He thought the weight was about 500 pounds.

A member had understood Mr. Preece to speak of a hand dynamo as something of a novelty. He had made a very efficient dynamo some time ago for the Medical Congress, with a permanent magnet resembling somewhat an Edison machine, which would work a Swan lamp very efficiently for surgical purposes. He could not give its resistance, but its price has been £25, complete with all the multiplying gear. It was much smaller and lighter than Mr. Preece's, but still sufficiently firm to stand without being fixed to the floor.

Mr. Ladd had had some considerable experience with hand dynamos as well as magnetos. He had himself introduced the first hand dynamo machine to that association at its Dundee meeting, when Sir Wm. Thomson was president. Since that time he had abandoned that principle altogether for what he considered a better one—to be found in the Gramme machine with permanent magnets. He thought that that had entirely superseded anything else that he had seen. He believed the dynamo principle good for large machines, but really not well adapted for a hand machine. The dynamo he had, however, heated a platinum wire of about 18 in. long, and that was as much as one man could do. In a Gramme machine one man can do the same thing very easily. He had found the best form of magnet to be of a circular form. If three magnets were put together for that purpose one man could do the work very easily. In the machine before them the enormous speed of the armature ought to produce a great effect, and it did, as shown by the sparks given; but, then, it was at the expense of three men. The machine reminded him somewhat of the machine by Giaraud, in Paris, a Ruhmkorff, where the disk was made to revolve between two poles of the magnet. But in that machine when a man was working it easily, directly the power was put on he was forced to stop instantly. He had made his machine feed two Swan lamps with the expenditure of one man-power.

Mr. Swan said that the hand Grammes had been very much restricted by the imposition of a very heavy royalty duty and their high price. He took it that the present machine was not hampered in that way. If he remembered rightly, the price of a hand Gramme, including royalty, in England was about £40, whereas Mr. Preece's exhibited dynamo only cost £15.

Mr. Preece said that the price of the dynamo was 350 francs, and the mechanical portion was additional, costing, say, another £5, so that they might put the whole cost of the machine as £20.

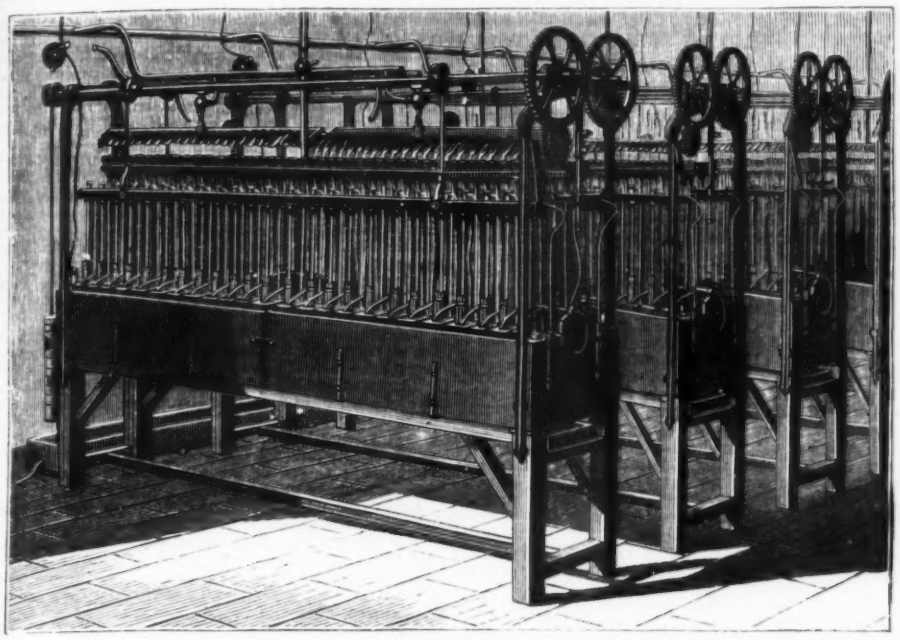


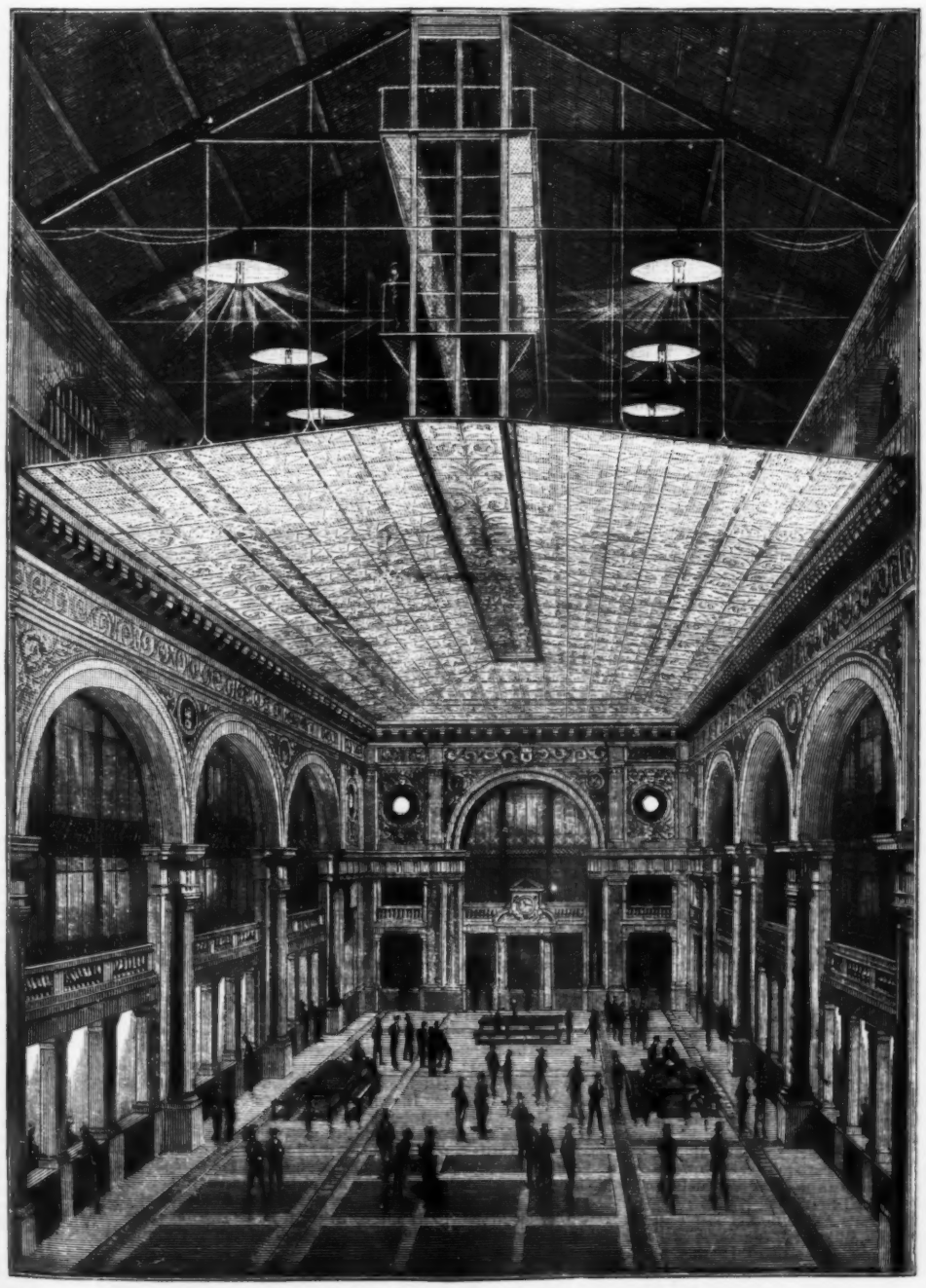
FIG. 2.—BICHROMATE OF SODA BATTERIES AT THE COMPTOIR D'ESCOMPTE.

Lord Rayleigh said that the general question raised by Mr. Ladd, as between dynamo and magneto, was of great interest. There seemed to be some presumption in favor of the magneto for a small current, as being more easily available within wide limits. Still he had always found the Gramme extremely convenient.

A member said that from his experience he had found that for small currents the hand magneto was capable of producing greater effect than the dynamo. His magneto was very effective with a small Swan lamp. He had also wrought a heavy sewing machine by its means, there being a boy only to turn it; but it was all that he could do.

[The machine was here again experimented upon, this time with perfect success, two men turning the machine produced three lamps of full power.]

Mr. Preece said they would notice in the lamps that excessively pretty violet light which indicated the last stage of the lamp's existence. If the velocity of rotation had been increased, perhaps ten times a second, or perhaps not so much, the three filaments of carbon would be broken with the strength of the current. The current was very nearly an ampère for each lamp. Hence, the three lamps were being wrought with an electromotive force of 70 volts, that gave them 210 units of power expended, units which he hoped would in future be known as Watts (applause). That was really 0·35 horse-power. If they added to that 10 per cent. for the work consumed by the machine, they formed an expenditure of about 0·4 of a horse-power in producing those three lamps, which was a very fair indication of the value of the instrument. He might add as to its weight, that three men had no difficulty in carrying it into the chapel. It could be used for the transmission of power, and for all experiments connected with the electric light, and to those who were in the habit of spending money in the acquisition of apparatus, he thought he could say that they would find the De Meritens machine exceedingly cheap.



GRAND SALOON OF THE COMPTOIR D'ESCOMPTE, PARIS, LIGHTED BY MEANS OF ELECTRIC BATTERIES.

TELEGRAPHING WITHOUT WIRES.

The *Dundee Advertiser* of September 6 has the following:

At the British Association meetings at Southampton, Mr. W. H. Preece, electrician at the General Post Office, adverted, in a paper on "Telephones," to an experiment he had made of telegraphing from the mainland to the Isle of Wight without employing a cable across the intervening space of water. This he accomplished by utilizing the property of electricity named induction. The efficiency of the telephone is frequently interfered with by currents of electricity being "induced" in the telephone wire by the electricity in telegraph wires, and Mr. Preece conceived the idea that as induction takes place sometimes in wires which are several miles apart, use might be made of this property to dispense with wires in certain cases. The purpose of wires is to carry the electric current, but if the current were ready to travel of its own accord without wires the saving in maintaining telegraphic communications would be very great.

This idea, however, is not a novel one. At the meeting of the British Association, held in Aberdeen, in 1859, the late Mr. J. B. Lindsay, of Dundee, read a paper, in which he described experiments almost as extensive and precisely the same in their method as that explained by Mr. Preece at Southampton the other day. In the days when our achievements with electricity are deemed so considerable, the humbler efforts of Mr. Lindsay are apt to be forgotten. There is no doubt, however, that he foresaw much that has only been accomplished within the last few years. His inventive faculty was keen, and he possessed the energy and perseverance, though unfortunately not always the resources, to work out his inventions. His studious disposition was remarkable, and if his talents had been developed in a sphere more suitable for them than the banks of the Tay, his name might have become famous in the annals of science. His prescience is exhibited in the following paragraph, which is taken from the *Dundee Advertiser* of August 7, 1835. It describes all the virtues of the electric light with as great completeness as though it had been written of a discovery by Edison or Swan:

"Mr. Lindsay, a teacher in town, formerly a lecturer to the Watt Institution, succeeded, on the evening of Saturday, the 25th ultimo, in obtaining a constant electric light. It is upward of two years since he turned his attention to the subject, but much of that time has been devoted to other vocations. The light, in beauty, surpasses all others, has no smell, emits no smoke, is incapable of explosion, and not requiring air, can be kept in sealed glass jars. It ignites without the aid of a taper, and seems peculiarly adapted for flax houses, spinning mills, and other places containing combustible materials. It can be sent to any convenient distance, and the apparatus for producing it may be contained in a common chest."

In 1836 Mr. Lindsay lectured on the electric light, and stated that as early as 1831 he had turned his attention to the subject. In a letter published by him in 1845 he suggested the possibility of laying an electric cable across the Atlantic, a dozen years before the project was seriously entertained. Afterward he developed a scheme for telegraphing across oceans without cables. He lectured at Glasgow, in 1853, on his theory of forming an electric communication between Great Britain and other countries without the employment of submarine wires, and the cost of such communication to America he calculated to be £60,000. A patent for his scheme was taken out in 1854, and several experiments were made by him at different places. The following paragraph appeared in the *Dundee Advertiser* of May 20, 1859:

"*Electric Telegraphing Across the Tay without Wires.*—We have received the following note from Mr. J. B. Lindsay, reporting progress with his experiments. The results, it will be seen, are highly encouraging: 'Yesterday (May 17) I telegraphed successfully across the Tay, opposite to Glencarse, where it is about half a mile broad. The action on the needle was strong, and the same battery power would cross, I think, at Broughty Ferry.'"

The dock authorities at Liverpool invited him to exhibit his invention on the Mersey, but owing to his apparatus having been deranged, his experiment in England was not successful. This caused skepticism as to the merits of the discovery, and he made renewed tests with it on an extended scale on the Tay. These fully realized his expectations. The *Dundee Advertiser* of July 10, 1860, contained a letter to the editor, in which Mr. Lindsay wrote:

"During last week I was engaged in making a telegraphic experiment across the Tay below the Earn, at a place where the river is more than a mile broad. The experiment was successful, and the needle was strongly moved, but, as I had no person with me capable of sending or reading a message, it was not attempted."

Meanwhile he had exhibited his scheme to the *savants* of the British Association at the meeting in Aberdeen in 1859. Experiments were made with it across the river Dee, and he read a paper describing its theory to the Mathematical Section, in the debate on which Lord Rosse, chairman of the section, and other leading scientists took part. Before quoting the condensed report of this paper, it may be well to quote the passage in Mr. Preece's paper on "Telephones," read at Southampton last week, in which he adverts to an experiment exactly on the lines of Mr. Lindsay's scheme:

"Mr. Preece had recently tried an extremely interesting experiment between this place (Southampton) and the Isle of Wight—namely, to communicate across seas and channels without the aid of wires at all. Large metal plates were immersed in the sea at opposite ends of the Solent—namely, at Portsmouth and Ryde, six miles apart, and at Hurst Castle and Sconce Point, one mile apart. The Portsmouth and Hurst Castle plates were connected by a wire passing through

Southampton, and the Ryde and Sconce Point plates by a wire through Newport; the circuit was completed by the sea, and signals were passed easily so as to read by the Morse system, but speech was not practical with the telephone."

The following is the report of the paper on "Telegraphing without Wires," read by Mr. J. B. Lindsay to the Mathematical Section of the British Association, at its meeting in Aberdeen, in September, 1859, which appeared in the *Dundee Advertiser*. After relating various minor experiments, he proceeded to describe his process, saying:

"Recently he had made additional experiments, and succeeded in crossing the Tay where it was three quarters of a mile broad. His method had always been to immerse two plates or sheets of metal on the one side, and connect them by a wire passing through a coil to move a needle, and to have on the other side two sheets similarly connected, and nearly opposite the two former. Experiments had shown that only a fractional part of the electricity generated goes across, and that the quantity that thus goes across can be increased in four ways: First, by an increased battery power; second, by increasing the surface of the immersed sheet; third, by increasing the coil that moves the receiving needle; and fourth, by increasing the lateral distance. In cases where lateral distance could be got he recommended increasing it, as by that means a smaller battery was requisite. In telegraphing by this method to Ireland or France, abundance of lateral distance could be got, but for America the lateral distance in Britain was much less than the distance across. In the greater part of his experiments the distance at the side had been double the distance across; but in the experiments in the Tay the lateral distance was the smaller, being only about half a mile, while the distance across was three-quarters of a mile. Of the four elements above mentioned, he thought that if any one were doubled the quantity of electricity that crossed would also be doubled; and if all the elements were doubled the quantity transmitted would be eight times as great. In the experiment across the Tay the battery was of four square feet of zinc, the immersed sheets contained about ninety square feet, the weight of the copper coil was about six pounds; the lateral distance was less than the transverse distance, but if it had been a mile, and the distance across also a mile, the signal would no doubt have been equally distinct. Should the above law (when the lateral distance is equal to the transverse) be found correct, the undermentioned table might then be formed.

"But supposing the lateral distance to be only half the transverse, then the distance crossed might be 16,000 miles, and if it was only a fourth, then there would be 8,000 miles, and thus a greater distance than the breadth of the Atlantic. Further experiments were, however, necessary to determine the law. Since last experiment he had increased the coil, and thought there was power to come two miles. According to this calculation, he thought a battery of 130 square feet, immersed sheets of 3,000 square feet, a coil of 200 pounds weight were sufficient to cross the Atlantic with the lateral distance that could be obtained in Great Britain."

The following is the table above referred to:

Zinc for Battery.	Immersed Sheets.	Coil.	Distance Crossed.
4 sq. ft.	90 sq. ft.	6 lb.	1 mile.
8 "	180 "	12 "	8 "
16 "	360 "	24 "	64 "
32 "	720 "	48 "	512 "
64 "	1,440 "	96 "	4,096 "
128 "	2,880 "	192 "	32,768 "

If Mr. Lindsay's hopes are to be realized, some great discovery yet remains to be made, for, by the laying of the Atlantic telegraph cables, we know that the electric current, transmitted across the wide expanse of the Atlantic, must be of extraordinary power to be apparent on the other side, even with a cable to lead it. Without a cable it would be hopeless to expect to find it, although the best apparatus were employed. Telegraphic instruments are greatly improved since Mr. Lindsay worked with them, and as regards batteries and coils he would find available for his purpose all that he could wish. No currents, however, are in use which would induce another current 2,000 or 3,000 miles away. Still it is within possibility that such may be found, and to a Dundonian must be ascribed the honor of having first conceived the scheme of transoceanic telegraph communication without the aid of cables.

ON ELECTRIC METERS.*

By C. VERNON BOYS.

MR. BOYS exhibited an extensive series of models bearing on the subject of power-measuring in general, which might be applied to electrical measurement in particular. The general principle was applicable to differential metronomy, and all the apparatus were based on the same idea, though the application made to the special case of measuring differences of potential was in one or two of the instruments exceedingly complicated. The fundamental idea utilized in the mechanism consisted in a wheel rotating in contact with a cylinder, but at an angle of about 30 degrees with the perpendicular cross section of the latter. The result was a transference of the rotating motion of the wheel into a longitudinal motion of the cylinder, if the cylinder was left free to move endwise. By a clockwork arrangement the wheel motion, when the cylinder had reached the end of its path, was transformed into a motion in the contrary direction, and thus the cylinder was forced to turn continuously within its field with an alternating to-and fro movement. The applications of this mechanical principle, which Mr. Boys described as comparatively novel, were described as numerous and of wide range. One instrument adapted as a differential electric meter was spoken of by Sir William Thomson as novel and highly ingenious. The apparatus consisted of two small magnetized steel cones, revolving on separate spindles, point downward, so that each spindle might be connected with a separate source of power. A small cross-piece of soft iron was hung between the cones, touching each of them with one end, and retained in position merely by the fact of the cones acting as magnets. When revolution was set up in the cones, the inventor showed that the cross iron remained always parallel to its original position if the two velocities were equal; but immediately that either of the cones moved more rapidly than the other, it was demonstrated that the angular displacement of the iron indicated with absolute accuracy the differential velocity of the spindles. Sir William Thomson, in remarking on the ingenuity displayed, stated that the latter instrument might be a valuable application in the measurement of potential differences between two electrical currents.

* From a paper read before the British Association.

THE THICKNESS OF WIRE NECESSARY TO CARRY DIFFERENT ELECTRIC CURRENTS WITHOUT OVERHEATING.

By PROF. G. FORBES.

ONE would expect that if one wire would carry a current of one volt, then two similar wires would carry two volts. This is so if the currents are very far apart, but when the currents are near together we have to take into consideration the surface from which radiation is continually taking place. Consequently, however likely it would seem at first sight that the current carried would be proportional to the section, as a matter of fact it is not so. I find by experiment that if there is a departure from the law of the square of the diameter, then the law is that the current is almost proportional to the diameter of the wire. If you can carry a definite amount of current through a wire of a millimeter of thickness without heating it over a temperature of 150°, then if you want to carry a current twice as great through a wire you must have one of two millimeters diameter—*i. e.*, four times the section. This is a very serious matter in regard to the extension of electric lighting. The method of arriving at the law was by taking pieces of wire of different diameters, putting a trace of beeswax upon them, and then by diminishing the resistance slowly so as to heat very gradually indeed, find the current necessary to melt the wax. Another very important law which is necessary for us to know in order to be able to change the type of dynamo so as to produce another which will give any desired electromotive force, is that when the wire is wound in coils so that the coils are the same size, then the strength of the current which is allowable is proportional to the square of the diame ter of the wire—*i. e.*, to the section. In determining this law I used small coils in tubes closed at one end, and filled with water of a definite temperature, then the current was raised by changing the electrical resistance until the temperature was definitely increased and the strength of the current was read off—this law being the result.

RECENT PROGRESS IN TELEPHONY.*

By WILLIAM HENRY PREECE, F.R.S.

THE telephone was first introduced to the British public at the meetings of the British Association. In 1876, at Glasgow, Sir William Thomson startled all his hearers by announcing the fact that he had heard, in Philadelphia, Shakespeare quoted through an electric wire, by the aid of the invention of Mr. Graham Bell, which he then pronounced to be "the greatest by far of all the marvels of the electric telegraph." In 1877, at Plymouth, I had the pleasure of showing in actual operation the finally developed instrument now known as the Bell Telephone, which I had just brought over from America, and conversation was actually maintained between Plymouth and Exeter. Five years have elapsed since then, and it is fitting that the British Association should hear of the progress made in the application of this astonishing apparatus.

In 1877, it was simply a scientific toy; it has now become a practical instrument. £1,550,000 capital is already embarked in its extension in England, and it is earning a revenue of £109,000. Hitherto it has been practically a monopoly in the hands of a private company, who hold the controlling patents, and of the Post-office, who possess the controlling power, but owing to the policy of the present Postmaster-General, this monopoly has been broken up, fresh patents have come into existence, and we are about to witness severe competition. It is often said that competition in any business will have the effect of reducing the rates charged to the public, but the experience of the past in railways and telegraphs scarcely teaches this lesson; competition does not always benefit the public. Undue competition tends to lower the rates for a time, but it eventually leads to amalgamation, to the absorption of the weak by the strong, to swollen and watered capital, and finally, in many instances, to higher rates to a too-confiding public. Competition, however, induces better service, and ultimately, in this respect, the public gain.

The free traffic in patents, however, leads to jobbery and speculation of the worst type. We have recently seen a mania for electric speculations that almost rivals the South Sea Bubble period. The public have wildly rushed into ill-matured schemes that have swollen the purses of gambling promoters, have turned the heads of inventors, have retarded the true progress of the beneficial application of this new science to the wants of man, and have thrown away millions upon imperfect schemes. Much has been said against the monopoly of the Post-office in telegraphic business, but it has, at any rate, the merit that it has checked the rapacity of company promoters and patent-mongers in that branch of the practical application of electricity, while no one can assert that it has checked the progress of telegraphy. During the first week that the telegraphs in this country were transferred to the State, the total number of messages transmitted was 26,000, while in the week ending August 11, it amounted to 724,000. There is no inventor who can assert that his scheme has not received proper consideration, nor show a real improvement that has not been adopted and remunerated; while the improvements of the Post-office itself are freely adopted by other countries, and America itself, the home of the inventor, has found the advanced system of England worthy of acceptance.

Receivers.—The original telephone receiver of Bell has scarcely been improved upon; it remains in form and construction very nearly the same as that which I exhibited in 1877. The perfection of its working depends upon the truth and perfection of its manufacture. It is now more solid and substantial than it was at first, more powerful magnets are used; but still it is the same simple, marvelous, and beautiful instrument that I brought over from America. Mr. Gower has increased its loudness by varying the form of its various parts, and using very powerful horse-shoe magnets of peculiar form; but experience shows that loudness is always obtained at the expense of clearness of articulation; and, although for many purposes the Gower-Bell instrument, which is adopted by the post-offices, and is now in use to connect together all the sections of the British Association scattered through the town of Southampton, is more practical, nothing for delicate articulation surpasses the original Bell.

The Paris Exhibition of last year, so fruitful in electrical novelties, did not bring forth any marked improvement in telephonic apparatus. It was noticeable chiefly for its practical applications of the telephone, and particularly to the transmission of singing and music to a distance. M. Ader's modification of Bell's receiver is that almost universally used in Paris. It is a very handy, pretty, and convenient form. He utilizes a principle which he calls "surexcitation." A thick ring of soft iron is inserted between the ear-piece and the diaphragm, and this is said to increase the attractive power of the little horse-shoe magnet upon the vibrating iron diaphragm. A simple experimental apparatus of M. Ader's shows that there is some foundation for this fact: when a thin steel spring is adjusted close to the poles of a magnet without being attracted by them, the near approach of a mass of iron to the spring will cause it to be attracted by the magnet.

D'Arsonval has also modified the Bell receiver. He has placed the coil in a powerful magnetic field of annular form, and has thereby concentrated the lines of force upon the induced coil. He brings the whole coil within the influence of the field. The effects are considerably magnified, and the increased loudness is not accompanied by the usual loss of articulation. Speech is said to be reproduced without any change of *timbre*.

Telephone receivers of the Bell type are all based upon the magnetic effects of currents of electricity flowing around magnets or bars of soft iron.

The rapid and rhythmic magnetization and demagnetization of a bar of iron, or the increment and decrement of the magnetism of a magnet, will produce molecular disturbances, in its own mass and in the matter about it, that lead to the oscillatory motions of the whole, which produce sonorous vibrations that can be made manifest by various devices, and particularly by that patented by Graham Bell.

Other principles of electricity have also been utilized for telephonic receivers.

For instance, Mr. Edison used the electro-chemical effect. The decomposition of a chemical solution in paper or on chalk by the passage of currents through it produces a modification of the friction of two moving surfaces, which can reproduce sonorous vibrations, and the result is a very loud-sounding apparatus. I myself had the pleasure, in 1880, of submitting to the Royal Society a receiver based on the electro-thermal effects of the current. The passage of a current through wires always heats them and therefore produces expansion. If the wire be made fine enough, the heat is generated and dissipated so rapidly, the expansion and contraction are so quick, that sonorous vibrations are the result. Although I was able to speak through it very clearly, I have not as yet developed this instrument into a practical form. Professor Dolbear has recently utilized the electro-static effects of currents. His receiver is even more simple than that of Bell. Two flat circular disks of metal are rigidly fixed very close to each other in an insulated case of ebonite. When one disk is electrified positively by a charge of electricity, the other is electrified negatively by induction. These two opposite states produce attractions varying in force with the strength of the signals sent, and the result is that, when telephonic currents are transmitted, we obtain sonorous vibrations, and consequently, the reproduction of speech.

Many other forms of telephone receivers have been devised and exhibited, in fact I have recently seen quite a crop of them; but as they involve no new principle, and introduce no particular improvement, having been brought out chiefly to try to avoid existing patents, I pass them over, and proceed to the next branch of my subject.

Our present patent law is, unfortunately, in so disorganized and chaotic a condition that evasion is often possible, and hence the questionable morality of doing a thing in another way in order to avoid the incidence of a royalty is practically encouraged.

The possession of a patent is now no guarantee of property; it is granted without any discrimination, and cannot be upheld without tedious litigation and wasteful expenditure before a non-technical and scientifically incompetent tribunal. We therefore cannot hope for any virtue in English inventors or security for real improvements until our law is thoroughly revised. The question is before the House of Commons, and when wordy agitators have fully exhausted the patience of our legislators, we may hope for some attention to so real and pressing a want.

Transmitters.—The great novelty and peculiarity of Bell's telephone was that the receiver and transmitter were similar and reversible. Sonorous vibrations of air impinging on an iron disk caused it to vibrate in front of a magnet, around one pole of which a portion of an electric circuit was wound. These vibrations of a magnetic substance in a magnetic field produced currents of electricity in the coil of wire on the magnet, varying in strength and direction with the sonorous vibrations, which, proceeding along a wire to a distant station, there varied the magnetic strength of a similar magnet so as to vary its attractive force on a similar disk, by which it reproduced the motions of the first disk, and thus, reproducing the sonorous vibrations of the air, repeated speech. The currents, however, were very feeble; much energy was lost *en route*, and the effect scarcely attained a practical standard. Mr. Edison showed how to strengthen these currents. Taking advantage of a peculiar property of carbon, which was supposed to vary in electrical resistance with the amount of pressure brought to bear upon it, he caused the vibrating disk which was spoken against to press upon a button of carbon, and so to vary the strength of a current of electricity passing through it. This varying current, passing through the primary wire of an induction coil, set up in the secondary coil more powerful currents than the Bell instrument produced, and caused louder and more marked effects at the receiving station. Professor Hughes went a step further. He found a combination of materials that were directly affected by sonorous vibrations, which he called a "microphone," and he proved that the effect of a carbon transmitter of Edison was not due to any influence of varying pressure on the mass of the carbon, but was a phenomenon of loose contact. He found a new fact in nature, and he startled the scientific world by introducing an instrument which did for minute sounds what the microscope had already done for minute objects. By the light thrown on the theory of the instrument by Hughes, Edison's carbon transmitter has been so improved by Blake, Hunnings, Moseley, Anders, and others, that little apparently remains to be done. The telephone as a speaking instrument is now well-nigh perfect. It is quite possible to swear to a friend's voice at 100 miles distance. The difficulty of making the telephone a practical instrument under all circumstances is not due to any defects in the instrument itself, but to disturbing influences external to it, and consequent on its surroundings. The very perfection and sensitiveness of the apparatus itself are its chief enemies.

The true action of the microphone, or carbon-transmitter, is very little understood; it introduces into a closed electric circuit, through which a current is flowing, a resistance which, varying exactly with the sonorous vibrations impinging upon it, causes the current to undulate in a way exactly analogous to the varying sound waves. This effect

* Paper recently read before Section G, British Association.

is generally assumed to be due to a greater or less intimacy of electrical contact between two semi-conducting surfaces abutting upon each other; but there is now little doubt that it is due to effects of heat generated by the passage of electricity between two points in imperfect contact, whose relative distance is variable. Carbon is the best material for the purpose—first, because it is inoxidizable and infusible; secondly, because it is a poor conductor; and thirdly, because it has the remarkable property of having its resistance lowered when it is heated—the reverse of metals. This observation is due to Mr. Shelford Bidwell.

The resistance of microphones is very variable: some only give 10, while others give 25, and some even 125 ohms. The best transmitters that I have worked with (Moseley's) give an average of 20.

Attempts have been made to apply mathematical analysis to the determination of the best form and arrangement of microphones, but at present the microphone defies mathematics.

Theory would lead to the conclusion that a carbon transmitter should have the lowest possible resistance, but practice does not confirm that idea.

Theory again asserts that the resistance of the secondary coil of the induction coil should be equal to that of the line it works, but practice proves the very reverse. On a line giving nearly 1,800 ohms resistance, the best effects were produced with a secondary wire of only 30 ohms resistance. The fact is that the conditions due to heat in the microphone, and to self-induction in the induction coil, are very complicated, and are not yet sufficiently understood to bring the phenomena they affect within the region of mathematical analysis.

Accessories.—I do not intend to speak here of the bells, calls, switches, etc., used in carrying out telephonic operations: there has been nothing that is particularly novel introduced, or that was not previously used in telegraphy. In fact, the whole operations carried on in connection with the so-called "exchange" working are simply telegraphic, and are still in a somewhat tentative condition.

Long-distance Speaking.—I have said that the difficulty in speaking is chiefly due to the environment of the wires employed. Were we to erect a wire from Land's End to John o' Groat's, upon lofty separate poles and away from all other wires, there would be no difficulty whatever in speaking between those two places. Conversation has been held in America over 410 miles; in Persia it has been effected between Tabreez and Tiflis, 390 miles apart; in India, over a distance of nearly 500 miles; in Australia, of 300 miles; but in all these cases it was done either at night or under exceptional circumstances, and in all cases the wires were overground. Had they been underground or submarine, the case would have been very different. Conversations have been held between Dover and Calais, between Dartmouth and Guernsey, and between Holyhead and Dublin, but I know of no case where any persons have spoken through more than 100 miles of submerged cable. The reason of this diminution of speaking distance is due to the electro static capacity of the telegraph line, which absorbs the minute quantity of electricity that makes up the currents employed for telephonic purposes.

In every submarine cable, before a signal can be made at the receiving end, the whole cable must be charged up with electricity, and if there be not sufficient electricity sent in to effect this purpose, practically no signal appears at the distant end. With telephone currents on long cables the whole of the electricity is, as it were, swallowed up—that is, none appears at the distant end, or, if it does appear, it is rolled up in one continuous wave, bereft of those rapid variations that reproduce sonorous vibrations. The newspapers said that the sound of the bombardment of Alexandria was heard at Malta; but, in the first place, the experiment was not tried, and, even if it had been tried, it could not have succeeded. The use of underground wires very seriously impedes telephonic extensions, and with our present apparatus and present knowledge we cannot readily speak over greater distances than 20 miles.

Disturbances.—But there are other disturbing influences at work of more serious import.

When two or more telephone wires run side by side, what is said on one can be overheard on all the others; and when a telephone wire extends alongside telegraph wires, every current on the telegraph circuit is repeated in the telephone, leading to a hissing, frying, bubbling sound that is not only very irritating, but which on busy lines entirely drowns speech. When music is transmitted on one wire, it can be heard equally well on all wires running parallel and contiguous. This is due to induction and to leakage.

(A.) *Induction.*—Induction is a term employed to designate the peculiar influence which electrified and magnetized bodies exert upon conducting and magnetic masses in their neighborhood. If two wires run side by side for some distance, every current of electricity sent upon one wire will produce two currents in the contiguous wire, the one at the commencement and the other at the end of the primary current of electricity. The greater the intensity, and the more sudden and abrupt the commencement and the ending of the inducing current, the greater effect it has on the induced wire. Those instruments, consequently, which reverse their currents the most rapidly and suddenly, produce the greatest disturbance. The powerful alternative and intermittent currents used for certain electric light systems are death to telephones: they cause an incessant roar that renders speech an impossibility. There are some apparatus in telegraphy that require very powerful currents to work them, which are equally detrimental. Many attempts have been made to cure this evil.

1. The sensitiveness of the receiver has been reduced to lessen the influence of the disturbing currents, and the strength of the telephonic transmitting currents has been increased so as to overpower the induced currents.

2. The influence of one wire on the other has been screened off by inserting metal coverings in connection with the earth between them.

3. The suddenness of the rise and fall of the inducing currents has been modified by the insertion of condensers or electro-magnets.

4. Counterbalancing or neutralizing effects have been set up by counter-induction apparatus.

But all these plans, and many others, have been proved either only partially successful or wholly abortive; the only effective mode of curing the evil at present practically used is to employ a complete metallic circuit, so contrived that the two wires are in very close proximity to each other, or that they twist round each other, so as to maintain a mean average equality of distance between themselves and the disturbing wires. When we have the two wires of a circuit kept at the same mean distance from the disturbing causes, however near they may be, the influence on each must be identically the same, and as the one is used for going and the other for returning, the similar influences must be opposite in direction, and they must therefore neutralize each other. This plan, which was originally devised for underground wires by Mr. Brookes, of Philadelphia, was found to be absolutely true in practice, and the Post-office, having laid down many hundreds of miles on this system with perfect success, invariably constructs its circuits, both underground or overground, in this way. It is, of course, more expensive than a single wire, but the great gain—the absolute freedom from overhearing the privacy, and the absence of crackling—is well worth the extra cost. Wires in submarine cables are invariably laid up with a twist, so that no special contrivance is needed on such wires, and in underground wires not laid up together as cables, they are, as a rule, so close to each other that twisting is unnecessary; but for overground purposes twisting is essential, and special arrangements have to be carried out. Professor Hughes showed how this was to be done, and Messrs. Moseley carried it out practically in the neighborhood of Manchester. The plan adopted by the Post-office *for two* and *for four* wires is shown by the diagram. It is simply and easily carried out, and entails no practical difficulty whatever.

In the neighborhood of Manchester there are over 400 miles of overground double wire twisted on this plan, working efficiently and thoroughly. I have spoken to a friend 76 miles off, through wires that were erected on poles carrying busily-occupied telegraphic currents, without disturbance or difficulty.

(B.) *Leakage.*—The double-wire system is only absolutely effective so long as the insulation is good. The moment insulation fails, connection with the earth is made, and then we have disturbing causes, due to currents flowing through the ground, which are increased in proportion to the deterioration of the insulation. Hence, good insulation is essential to telephone working.

The discovery of the telephone has made us acquainted with another phenomenon. It has enabled us to establish beyond doubt the fact that currents of electricity actually traverse the earth's crust. The theory that the earth acts as a great reservoir for electricity may be placed in the physicist's waste-paper basket, with phlogiston, the materiality of light, and other hypotheses. Telephones have been fixed upon a wire passing from the ground floor to the top floor of a large building, the gas pipes being used as a return, and the Morse signals sent from a telegraph office 250 yards away have been distinctly read; in fact, if the gas and water systems be used, it is impossible to exclude telegraphic signals from the telephone circuit. There are several cases on record of telephone circuits miles away from any telegraph wires, but in a line with the earth terminals, picking up telegraphic signals. When an electric light system uses the earth, it is stoppage to all telephonic communication in its neighborhood. The whole telephonic communication of Manchester was one day broken down from this cause, and in the City of London the effect was at one time so strong as not only to destroy telephonic communication, but to ring the bells. A telephone circuit using the earth for return acts as a shunt to the earth, picking up the currents that are passing, in proportion to the relative resistances of the earth and the wire. The earth offers resistance, and consequently obeys the law of Ohm; hence it is not only essential for a telephonic system that the earth should not be used on any electric light system, but it is also desirable that the earth should be eschewed for telephonic purposes. Thus, the double-wire system adopted by the Post-office and by the Société Générale des Téléphones of Paris, not only cures the ill-effects of induction, but it materially diminishes the disturbing influences of earth conduction. The four-wire system of the Post-office effectually checks leakage from one wire to the other, cross contact, as we call it in England, for each wire of the same current is always on a different supporting arm.

A telephone circuit when in connection with the earth gives distinct evidence of every visible flash of lightning, however far off the thunderstorm may be. No difference in time has been observed between seeing the flash and hearing the crash.

It is said that if a telephone be connected between the gas and water systems of a house, distinct evidence of every flash can be heard. There have been several cases of persons being knocked down while experimenting during a thunderstorm, but no personal injury has been sustained, although the apparatus itself is frequently damaged. In England, at present, we have not found the damage done sufficient to justify the employment of lightning protectors. The use of double wires diminishes the danger to a minimum. On the Continent and in America, however, telephones are invariably protected by lightning arresters where one wire only is used.

There are certain natural currents flowing through the crust of the earth. They are called "earth" currents, and at times acquire such considerable energy that with a telephone pressed to each ear, I have been told, although I have not experienced it, that the noise made is as though "your brains were boiling." This is due to the intermittent currents produced by the polarization of the earth plates.

M. Van Rysselberghe has recently spoken between Paris and Brussels upon a wire nearly 200 miles long, which was used at the same time for ordinary telegraphy, but the experiment was made early in the morning (4 A.M.), and was effected by retarding the telegraphic currents, so as to modify the suddenness of their rise and fall, by means of condensers and electro-magnets. I am unable to understand the advantage of any gain in speaking on a wire which is detrimental to telegraphic communication. Speed is of more importance than speech, and we can telegraph much faster than we can speak. In England speed is everything, and we eliminate every influence that retards speed—condensers and electro-magnets in telegraph circuits are out of the question. M. Van Rysselberghe has endeavored to extend the idea to cure the effects of induction by destroying the main cause of the disturbance—that is, by reducing the sudden rise and fall of the prime telegraphic currents; but to do this means to retard telegraphy, and we cannot afford in England to cripple the one system in order to benefit the other.

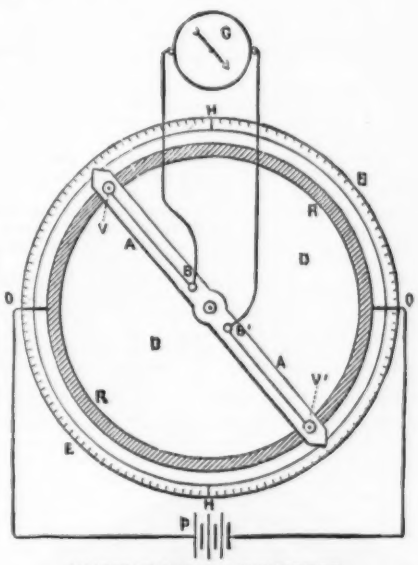
I have recently tried an extremely interesting experiment between this place (Southampton) and the Isle of Wight, namely, *to communicate across seas and channels without the aid of wires at all.* Large metal plates were immersed in the sea at opposite ends of the Solent, namely, at Portsmouth and Ryde, six miles apart, and at Hurst Castle and Sconce Point, one mile apart. The Portsmouth and Hurst Castle plates were connected by a wire passing through Southampton, and the Ryde and Sconce Point plates by a wire passing through Newport; the circuit was completed by the sea, and signals were passed easily so as to read by the Morse system, but speech was not practical.

The telephone is very rapidly gaining ground, and as improvements are effected in its accessories, in its installation, and in its mode of working, its use will still further extend. In Germany it is used very extensively for telegraphic business, there being 1,280 stations worked entirely by telephones; but in England it is not possible in the numerous open and public shops employed as post offices to secure that privacy which the telephones require, nor have we yet got over our early prejudices, resulting from the errors made through the inability of the instrument in its earlier form to repeat the sibilant sounds. The instruments of the present day (thanks to the improved transmitters), however, transmit "Esses" perfectly. By Mr Smith's inductophone it is quite possible to make use of air between us to hear perfectly; so that air conducts sound, so does water, so does wire, and indeed with our present knowledge our difficulty is not so much to make things speak as to prevent them from speaking.

WARTMANN'S RHEOLYZER.

THIS apparatus, which Mr. Wartmann has just described in the May number of the *Archives des Sciences Physiques et Naturelles*, had already been presented by its author to the Societe de Physique et d'Historie Naturelle de Geneve, in 1877. It is a Wheatstone bridge of peculiar form, in which the intensity of the current passing into the branch of the galvanometer may be made to vary, and which, consequently, permits of utilizing such current by graduating its intensity as need may be.

The principle, if not the exact arrangement of the apparatus, is represented in the accompanying cut. D D is a thick glass or ebonite disk surrounded by a copper circle, E E, graduated in each arc from 0° up to 90°. This disk, which is supported by a standard provided with leveling screws, carries a circular groove, R R, filled with mercury. A A is an alidade of insulating material, placed a little above the disk, and which, revolving around the center of the latter, carries two amalgamated-pointed screws at its extremities that continue during its motion to dip into the mercury. At the extremities, O O, of a same diameter, end the wires coming from the poles of a pile, *p*, and at the terminals, v v^1, end the wires of a galvanometer after passing through the pieces, B B^1.



WARTMANN'S RHEOLYZER.

We have here, then, a true Wheatstone's bridge, in which, when the alidade is perpendicular to the diameter, O O, the current passing into the galvanometer is null; but in which, on the contrary, when the alidade coincides with O O, the current passing into the branch of the galvanometer is maximum.

For intermediate positions, it is easily found that the intensity is proportional to the angle that the alidade makes with the diameter, H H.

If we designate by I the intensity of the current of the pile (supposed constant) outside of the apparatus; by i, that of the derived current that passes through the bridge and galvanometer; by ρ, the resistance of such derived circuit, and by r^1, r^2, r^3, r^4, the resistances of the mercurial arcs comprised between the extremities of the bridge and the points of division of the principal circuit, we shall have, according to the laws of Kirchhoff,

$$i = I \frac{r^2 r^3 - r^1 r^4}{(r^1 + r^2)(r^3 + r^4) + \rho (r^1 + r^2 + r^3 + r^4)}$$

In the rheolyzer,

$$r^1 = r^4 \text{ and } r^2 = r^3.$$

Let us call R the resistance of half of the ring,

$$R = r^1 + r^2 = r^3 + r^4,$$

which gives

$$i = I \left(\frac{r^2 - r^1}{R + 2\rho} \right).$$

So, starting from the position of compensation, where $r^2 = r^1$, the intensity of the derived current increases proportionally to the arc whose bridge has been displaced. It is easy to make sure of this, moreover, with a sinus compass.

If $r_1 = 0$, the value of i becomes maximum, and may be written

$$I = i \left(\frac{R}{R + 2\rho} \right).$$

When $\rho = \frac{R}{2}$, we have $i = \frac{I}{2}$, a value that would be obtained by giving the channel a section 30 times greater than that of the copper conductors, and the galvanometer a resistance equivalent to a quarter that of the mercurial ring.

The rheolyzer may be employed for the following purposes:

1. To obtain a current of given intensity.
2. To maintain such intensity with the utmost constancy.
3. To verify, by an operation similar to that of a commu-

tator, the construction and installation of apparatus founded upon electro-magnetic reactions, such as sinus and tangent compasses, galvanometers, etc. The movable part is in its true position of equilibrium, protected from every disturbing cause, when it deviates by arcs that are equal to each other under the action of equal and successively opposed currents produced by the displacements of the bridge from the two zero sides.

4. To directly determine the value of the coefficient of reduction which renders comparable the valuations effected by means of two of these apparatus that are not identical. Such coefficient is equal to the ratio of the lengths of the mercurial arcs, reckoned from the zero of compensation, for which the deviation of the movable part is the same in both instruments.

5. To establish a table of correspondence between the intensities of different currents and the galvanometric deviations which measure them.

6. To form a table of such corrections as are necessary to be made in the indications of ordinary tangent compasses.

7. To find the ratios of intensity of the electromotive forces that are derived from different sources. Such intensities are to each other in a ratio inverse that of the arcs of the rheolyzer that produce a same deviation in the galvanometer.

8. To estimate the ratios of the resistances of different conductors, as well as the variations of the resistance in a same conductor.

9. To insure of the perfect construction of shunts, resistance coils, and other apparatus of the same kind; and

10. To express in absolute measurement the intensity of derived currents, when we know the value of I, as well as that of the resistances, R and ρ —*La Lumiere Electrique.*

HYDRAULIC ORGANS.

The most perfect musical instrument that was ever known to antiquity was certainly the *hydraulic organ*, which filled with its powerful voice those arenas in which the gladiator fought. Petronius relates that Nero one day made a vow to play on one of these himself in public if he should escape a danger that was threatening him. The invention of these instruments is attributed to Ctesibius, who lived at Alexandria in the second century before our era. After having been a barber during his youth, Ctesibius was enabled, through the skill of his wife Sais on this instrument, to acquire sufficient wealth to have all those ingenious machines constructed which have caused his name to be transmitted to posterity.

The learned have, up to the present time, been little decided as to the construction of the water organ, as may be seen by consulting the article devoted to it in Rich's "Dictionary of Antiquities."

Vitruvius has indeed described it, but so obscurely that the last translator of the Roman architect (Panckoucke's edition, 1847), at his imagination's end, exclaims: "What figure will ever make known the true form of these ancient organs? The description of them given by Vitruvius cannot, as he himself says, be understood by any but those who know the instrument from having practiced on it. Now, where are we to find any ancient organs? What antique monument shall enable us to understand them through some representation that has been preserved?" Well! such a monument exists, and it is found in the writings of Heron, that inexhaustible and unexplored mine for everything relating to ancient mechanics. Our readers shall be convinced of this. According to my custom, I shall translate literally, permitting myself to suppress a few letters that overload the figure without rendering it any clearer. The cut shown

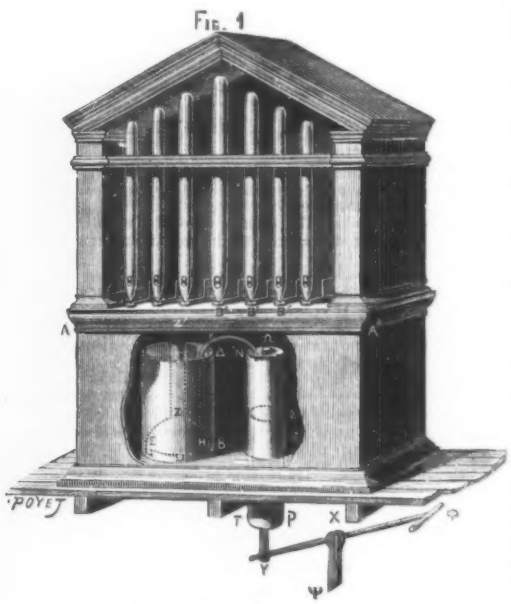


Fig. 1.—HYDRAULIC ORGAN.
(After Heron, of Alexandria.)

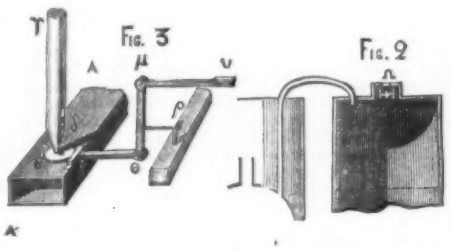
in Fig. 1 is only a reproduction of the one given in manuscripts, but which is rendered more correct and more striking than the unskilled hands of copyists could have made it.

CONSTRUCTION OF A HYDRAULIC ORGAN.

Let BΔ be a bronze altar* containing water. Let there be in this water an inverted hollow hemisphere called the extinguisher, EZH, leaving a passage for the water all around its base,† and from the top of which two tubes in communication with its interior rise outside of the altar.

One of these tubes, HK, is bent externally and communicates with a pyxis,‡ NΠ, whose aperture is below, and whose internal surface has been bored out in order to receive a piston, PΣ, which must fit very accurately so as to allow no air to pass. To this piston there is fixed an extremely strong rod, TΥ, to which is adapted another rod, $\Upsilon\Phi$, movable around a pin, Υ.§ This lever should move on a securely fixed vertical road, ΨX. On the bottom of pyxis, NΠ, there is placed another and smaller pyxis, Ω, which communicates with the former, and which carries at its upper part a cover containing an aperture for allowing air to pass into it. Beneath this hole, and for closing it, there is arranged a thin plate held by four pins which pass through holes in it and which are provided with heads so as to prevent it from falling This plate is called *platysmation* (Fig. 2). The other tube, ZZ', rises from the hemisphere EZH, and ends in a transverse pipe, AA',† against which rest tubes communicating with it and having at their extremities *glossocomes*,‡ that communicate, themselves, with such tubes, and whose orifices are open. Across these orifices there slide perforated covers§ in such a way that, when they are pushed toward the interior of the organ, their apertures correspond with the orifices of the pipes (and to the orifices of AA'), and that, when they are drawn back, there is no longer any correspondence, and the pipes are closed.

If, now, the transverse rod, $\Upsilon\Phi$, be lowered at Φ, the piston, PΣ, will rise and compress the air in the pyxis, NΞOΠ, and this air will close the aperture of the small pyxis by means of the platysmation described above. It will pass then, by means of the tube, KH, into the extinguisher; then, from the latter into the transverse tube, A'B', through the tube, ZZ',; and, finally, from the transverse tube into



Figs. 2 and 3.—DETAILS OF HYDRAULIC ORGAN.

the pipes if the orifices correspond with the holes in the covers—this taking place when all the covers, or only a few of them, have been pushed toward the interior.

In order that their orifices may be open when it is desired to cause certain ones of the pipes to sound, and that they may be closed when it is desired that the sound shall cease, the following arrangement will be employed:

Let us consider by itself one of the mouths situated at the extremity (Fig. 3). Let $\gamma\delta$ be such mouth; δ its orifice; AA', the transverse pipe; and, finally, σ, the cover, which, at this moment, does not coincide with those of the pipes. Let there be, now, an articulated system composed of three rods, $\theta\mu\nu$, the rod, $\varepsilon\theta$, being attached to the cover, σ, and the system as a whole moving around a pin, μ. It will be seen that if we lower the extremity, ν, of the system with the hand toward the orifice of the glossocomes, we shall cause the cover to move toward the interior, and that when it has reached there its orifice will coincide with those of the pipes. In order that, on removing the hand, the cover may be spontaneously carried again toward the exterior and close all communication, we may employ an arrangement like the following: Fix under the glossocomes a ruler equal and parallel to the pipe, AA', and to it affix solid pieces of horn bent like the one marked ρ, seen opposite $\gamma\delta$; and at the end of this piece of horn fix a cord which shall run to the extremity, θ, so that when the cover is pushed toward the exterior the cord will be stretched. If, then, the extremity, ν, be depressed, and the register be thus pushed toward the interior, the cord will draw upon the piece of horn, and, by its power, straighten it. But, as soon as the pressure is removed, the horn will assume its first position, and draw the cover backward so as to prevent its orifice from setting up a communication. Such an arrangement being adopted for each of the glossocomes, it will be seen that, in order to cause any one of the pipes to sound, it will only be necessary to depress the corresponding key with the finger; and that when, on the contrary, we desire to stop the sound, we shall only have to raise our finger, and the effect will be produced by the displacement of the cover.

Water is poured into the small altar, so that the compressed air driven from the pyxis, NΠ, may, owing to the pressure of such water, be kept in the extinguisher and thus supply the pipes.

The piston, PΣ, when raised, drives the air, then, into the extinguisher, as has been explained; since, when it is lowered, it opens the platysmation of the small pyxis. By this means the pyxis, NΠ, fills with air from the outside, and this air the piston when again raised drives anew into the extinguisher.

At the beginning of the seventeenth century Porta caused a hydraulic organ to be constructed at Naples on the plan that I have just set forth; and a few years afterward, Kircher constructed another one at Rome for Pope Innocent X. These organs had the defect that they did not give the note, although they gave a series of harmonic sounds. On another hand, they produced an extremely agreeable *tremolo*. It was probably such unusual variations in sound that charmed the ears of the Greeks and Romans. Heron afterward describes a bellows organ, the motion of which is given, not by the arm of man, but by the action of a windmill. Fig. 4 requires no explanation; it is interesting because it carries the origin of windmills as far back at least as the second century before our era, although it has been asserted that they were unknown to antiquity, because Vitruvius and Varro do not speak of them.—*A. de Rochas, in La Nature.*

* Altars were cylindrical or square pedestals, characterized by a hollow cavity in the upper part in which the fire was lighted.

† Vitruvius said that such a result is obtained by allowing it to rest on four supports.

‡ A cylindrical box performing the role here of pump chamber.

* The cut shows another arrangement.

† Called *sound board* in a modern organ.

‡ Flute mouth-pieces.

§ Registers.

A PROJECTING PHENAKISTICOPE.

Plateau's phenakisticope, the zootrope, and all apparatus derived from it, are capable of operating only in the presence of a very limited audience. It is necessary to hold the apparatus in the hand in some way, and only two or three persons can observe its effects. These apparatus, however interesting they may be, cannot be utilized, then, in courses of instruction or in lectures.

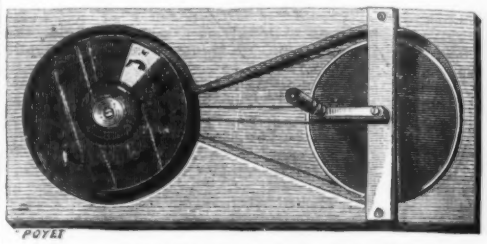
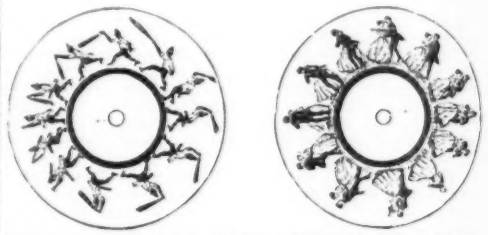


Fig. 1.—PROJECTING PHENAKISTICOPE.
(⅓ actual size).



Figs. 2 and 3.—GLASS DISKS OF THE APPARATUS.

The phenakisticope which we represent herewith can be adapted to the ordinary oxyhydrogen or electric light projecting lanterns, and the object which is placed therein is capable of being projected upon a screen and of being seen by a very numerous audience at once. The images are rotated by means of a winch. The latter, through the intermedium of two small endless cords, transmits motion, on the one hand, to an opaque disk containing a window of the size of one of the images, and, on another hand, to the glass plate on which are painted the designs; the glass plate and the disk (shown to the left of Fig. 1) revolve in opposite directions. The transmitting cords, which are seen in the same figure, roll around the channel and axle of a pulley that the winch sets in motion. The velocity with which the window rotates is thus much greater than that of the glass disk.

The projection thrown on the screen gives a perfect sensation of motion. This little apparatus, which will prove very useful for teaching, is constructed by Mr. Molteni. We make our description more complete by giving specimens of two of the disks containing zootropic figures (Figs. 2 and 3). The first glass disk shows a gymnast raising and lowering a club, and the second, a couple of waltzers.—*La Nature.*

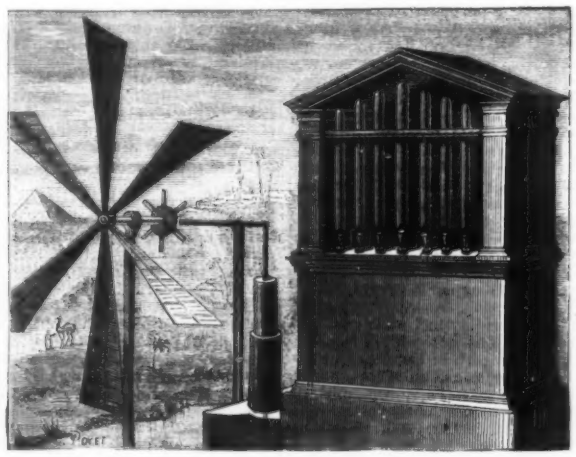


Fig. 4.—WINDMILL ACTUATING THE BELLOWS OF AN ORGAN.

THE FORTH BRIDGE.*

By B. BAKER.

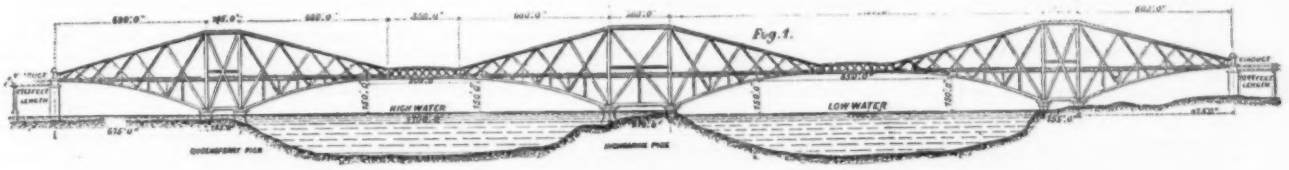
AT the request of Dr. Siemens the following short paper on the proposed Forth Bridge has been prepared, though the author himself would have preferred to postpone any communication on the subject to the British Association until the works were well in hand, and the many points of interest and difficulties inseparable from so gigantic an undertaking had manifested themselves. At the present moment a commencement has not been made, the whole period from the revival of the project last year until now having been occupied in the necessary preliminary work of obtaining the act of parliament and preparing the designs and specifications. It is believed, however, that in a few weeks the contract will be let, and an energetic start will at once be made with the works.

Before referring in detail to the history of the undertaking and to the character of the design, the author would like to convey, if possible, some notion of the magnitude of the proposed bridge across the Firth of Forth. In preparing the detailed designs he has often experienced no little difficulty in realizing the scale upon which he was working. For example, the bedplates for an ordinary railway girder bridge, say a couple of hundred feet span, would be about half the size of an ordinary dining table, and it is difficult at first to picture to one's self a bedplate about double the size of an ordinary dining-room; but that is the size of the bedplates for the Forth Bridge girders. A diagram hanging on the wall shows the comparative sizes of some of the largest girder and arched bridges in the world; but even this fails, in the author's opinion, to impress upon the mind the vast difference in scale between the proposed and all previous bridges. On glancing through the last volume of "Reports of the British Association," with a view to obtain a notion as to the ordinary length of papers for Section G, he incidentally obtained a notion also for illustrating, in popular but perfectly accurate terms, the size of the Forth Bridge as compared with the largest bridges in this country. In the report of the Anthropometric Committee it was stated that the average stature of a new-born infant is 19·34 in., while the average height of the guardsmen sent out to Egypt has been officially given at 5 ft. 10¼ in. These figures have a ratio of 1 to 3·65, and, singularly enough, as the largest railway bridge in this country, the Britannia Bridge, has a span of 461 ft., and the Forth Bridge a span of 1,700 ft., the ratio there also is 1 to 3·65. Hence, to enable any one to appreciate the size of the Forth Bridge, we have merely to suggest the following simple rule-of-three sum: As a grenadier guardsman is to a new-born infant, so is the Forth Bridge to the largest railway bridge yet built in this country. Bridges a few feet larger in span than the Britannia have been built elsewhere, but they are baby bridges after all.

Such being the size of the structure, the question naturally occurs, why it should be necessary or expedient to build so unprecedented a work far north in this little island of Great Britain, when it has been found practicable to cover the globe with railways and to carry roads across the greatest continental rivers without involving any such difficult undertaking. The answer is a somewhat complex one. It is not the physical features of the country, but the habits of the population that render the construction of a 1,700 ft. span expedient. If the British public can save a few minutes by going a particular route, by that route will they go, although the alternative one might be as eligible, or even more so, in every other respect. This fact was forced upon the attention of the North British Railway Company nearly twenty years ago, when they sought powers to construct a bridge across the Forth, to secure for themselves and their allies the Great Northern, North-Eastern, and Midland Railways a fair share of the through traffic between England and the North of Scotland, which they alleged had been hitherto practically monopolized by the London and North-Western and the Caledonian Railways, whose route was a few miles shorter. Parliament, satisfied, no doubt, that the contention was a reasonable one, granted the solicited powers in the year 1865. The bridge then proposed crossed the Forth at a different spot to the present bridge, as the engineer had not the courage to face a span of 1,700 ft., and nothing less is practicable at Queensferry. Owing to the treacherous character of the foundations, however, it became necessary to adopt another site, and by bringing the point of crossing five miles further down stream to Queensferry, a considerable saving in distance was effected in the route between Edinburgh and Perth.

The Act for constructing a bridge at Queensferry was obtained in 1873. At this point the Firth of Forth is divided by the island of Inchgarvie into two unequal channels, but the depth of water in each is such that a smaller span than 1,700 ft. could not be economically adopted for either channel. North of Inchgarvie the maximum depth of water is 218 ft., and south of the same 197 ft. In the former channel the bottom is of hard trap rock, and in the latter, partly of rock and partly of extremely stiff bowlder clay. It is not the treacherous character of the bed of the Forth, therefore, but the depth of water which precludes the construction of intermediate piers. Pneumatic apparatus is inapplicable to such depths as 200 ft., and no responsible engineer would care to found the piers of an important structure upon a bottom which he had no means of examining by diving apparatus or otherwise.

To the late Sir Thomas Bouch is due the credit of the bold proposition to cross the Forth in two spans of 1,600 ft., and to so avoid the necessity of intermediate piers in unprecedented depths of water, with all the consequent uncertainties and contingencies. A contract for the construction of Sir Thomas Bouch's great suspension bridge was made with Messrs. Arrol, and the preliminary works were in progress when the Tay Bridge fell. In consequence of the latter catastrophe, the directors of the Forth Bridge Company decided not to proceed with the works, and an Abandonment Bill was consequently promoted in the session of 1881. The North British, Great Northern, North-Eastern, and Midland Railway Companies, being interested in securing direct communication to the North of Scotland, objected to the abandonment of the enterprise, and instructed their respective consulting engineers, Mr. Fowler, Mr. Harrison, and Mr. Barlow to report anew on the practicability and cost of crossing the Forth, either by a bridge or otherwise, at Queensferry or elsewhere. A careful reinvestigation of the whole question was accordingly made, with the result that the directors were advised that it was perfectly practicable to build a bridge across the Forth which would comply with all the requirements of the Board of Trade and public safety, and that the best place of crossing was at Queensferry. The Abandonment Bill, which had passed the Commons, was then withdrawn, and the engineers were instructed to agree upon a design. Modifications of the original suspension bridge were first considered, and Mr. Fowler and the author then submitted a project for a bridge on the continuous girder principle. Mr. Harrison and Mr. Barlow, fully appreciating the advantages which would pertain to such a bridge as compared with a more or less flexible suspension bridge, made independent investigations, and suggested several modifications. Finally, the design now before you was unanimously agreed upon by all as the one to be recommended to the directors for adoption. The directors acted upon this recommendation, and, accordingly, the necessary plans were deposited, and an Act was obtained this year for constructing a continuous girder bridge across the Forth at Queensferry, having two spans of 1,700 ft., two of 675 ft., fourteen of 168 ft., and six of 50 ft., and giving a clear headway for navigation purposes of 150 ft. above high-water spring tides. For this work Mr. Fowler and the author are acting as engineers.



THE FORTH BRIDGE.

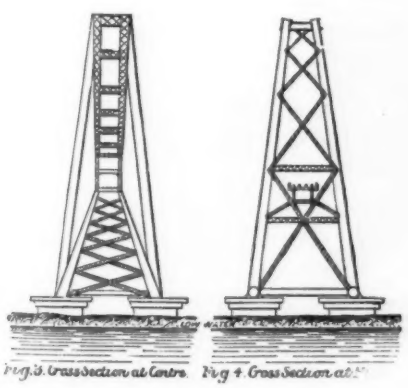
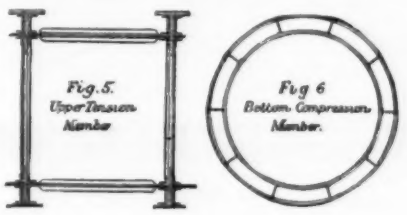


Fig. 3. Cross Section at Centre. Fig. 4. Cross Section at A.



It is unnecessary to refer in detail to the mode of erection, as it is obvious that the work will be commenced at each pier, and be proceeded with by adding successive portions to the ends of the cantilevers until the same are complete. The central girders will also probably be erected on the overhanging system, temporary connections being formed between the ends of the cantilevers and the central girder. The closing lengths or key pieces at the center of each 1,700 feet span will be put in on a cloudy day, when there is little variation in temperature, and the details will be so arranged that the key piece can be completed and the temporary connections cut away in a few hours, so as to avoid any temporary inconvenience from expansion and contraction.

No special difficulty will arise with respect to the foundations, though the works will be, of course, on an unusually large scale. The island of Inchgarvie is of trap rock, and the central pier at that spot will consist of four cylindrical masses of concrete and rubble work faced with granite, and having a diameter of 45 feet at the top and 70 feet at the bottom. The height above high water will be 18 feet, and the depth below the same will vary from 24 feet to 70 feet. After the sloping face of the rock foundation has been cut into steps, wrought-iron caissons will be floated out, lowered into place, and filled with concrete lowered through the water in hopper-bottomed skips. Queensferry pier will be founded on bowlder clay. Open topped cylindrical caissons, 70 feet in diameter, with an external and internal skin 7 feet 6 inches apart, will be floated out and lowered into place. The space between the skins will be filled with concrete, to give strength and weight to overcome frictional resistance in sinking. Grab excavators will be carried on a turntable top to the caissons to remove the earth from the interior, and pneumatic apparatus will be supplied to enable men to clear bowlders from the cutting edge of the caissons. From a depth of 6 feet below low water upward, the masonry will be built in the dry, inside a movable caisson connected by an India-rubber joint with the permanent caisson below it. The piers will be carried down at least 10 feet into the bowlder clay, which will give depths ranging from 68 feet to 88 feet below high water, and 18 feet less at low water in the respective cylinders. In round numbers the weight of one of the cylindrical piers at Queensferry may be taken at 16,000 tons, and the combined vertical pressure on the top of the pier from the dead weight of superstructure, rolling load, and wind pressure at 8,000 tons; so the load on the clay would average about 6 tons per square foot over the area of the foundation. This is an insignificant amount on such hard clay as that at the Forth, and the margin is ample, therefore, to allow of the unequal distribution of the pressure due to the action of partial blasts of wind and of a certain amount of expansion in the tubes connecting the piers.

The total length of the great continuous girder is 5,330 feet, or say a mile, and of the viaduct approaches 2,754 feet, or rather over half a mile. There is nothing calling for special remark in the viaduct. The piers will be of rubble masonry, faced with granite, and the superstructure of iron lattice girders with buckled plate floor and trough rail bearers, as in the instance of the main spans. The main girders, spaced 16 feet apart, will be placed under the railway, and there will be a strong parapet and wind screen to protect the trains.

To engineers little need be said respecting the stiffness of a girder bridge having the proportions adopted in the present case. The central girder has a depth of one-seventh of the span, while the cantilevers may be looked upon as halves of a girder having a depth of one-fourth of the span. Exceptional depths like these confer exceptional stiffness, and there is the additional fact that the live load of a passing train will be quite insignificant as compared with the dead load of the structure. The heaviest train traversing the bridge will not deflect the 1,700 feet girder more than 4 inches, which is considerably less than the deflection of the 460 foot span of Saltash Bridge under its test load, while a wind pressure, equivalent to 30 pounds per square foot over the entire 1,700 feet, would bend the bridge laterally less than 9 inches.

About 42,000 tons of steel will be used in the superstructure of the main spans, and 3,000 tons of wrought iron in that of the viaduct approach. The total quantity of masonry in the piers and foundations will be about 125,000 cubic yards, and the estimated cost of the entire work, upon the basis of the prices at which the original suspension bridge was contracted for, is about £1,500,000. Owing to the varying price of steel, and to the magnitude and novelty of the undertaking, this estimate must be taken as approximate only, as a contract has not yet been concluded for the works.

It will be gathered from the preceding necessarily brief and incomplete description of the proposed Forth Bridge, that no novel or untried elements enter into the design. In principle, a continuous girder is as old a type of construction as an arch or a suspension bridge; and probably, in prehistoric times, streams were crossed by the aid of a couple of overhanging branches, and an intermediate central portion constituting a structure, rude in appearance, but identical in principle with the great bridge. The merit of the design, if any, will be found, not in the novelty of the principles underlying it, but in the resolute application of well-tested mechanical laws and experimental results to the somewhat difficult problem offered by the construction of so large a bridge across so exposed an estuary as the Firth of Forth.

* Abstract from a paper lately read before Section G at the British Association.

TRIAL OF A FOLDING BOAT.

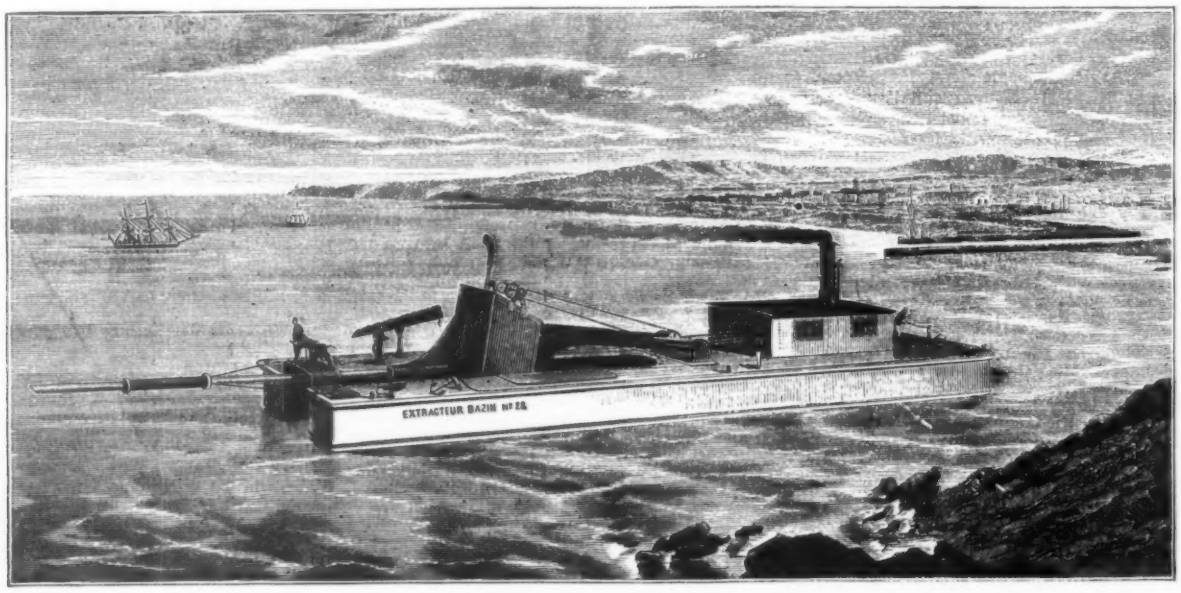
IT has been believed by many that the remarkable collapsible boats invented by Rev. E. L. Berthon, and now coming into general use in England, though good for some purposes, could never stand the test of a gale of wind or compete with other boats in sailing powers. To prove the fallacy of this opinion, Captain Frederick Harvey, R.N., and Captain Whalley Nicholson ventured to take an ocean trip in a 28 foot boat of this kind, built at Romsey for the Union Company. With four seamen they embarked in the S.S. Esequibo, by the permission of the Royal Mail Company, on the 11th August. On the 14th, the boat and its crew were put overboard about 400 miles west of the Scilly Isles. There was a very strong wind and high sea. Owing to the thick weather and constant rain the boat's crew got no observations, and when they ascertained their whereabouts by hailing a ship, they found themselves about sixty miles west of Cape Finisterre; they then bore away more to the north, and reached the Scilly Isles on the 19th at 3 A.M. Here they stayed till Sunday, the 20th, at 4 P.M., when in more than half a gale of wind they started again for Southampton, and made the wonderful run of 240 miles to the Needles in thirty-five hours. The *Engineer* believes this is quite unprecedented for a ship's boat. Sometimes they logged more than ten knots an hour. That an open canvas boat should live in such a stormy sea as would have swamped any other is remarkable enough; but that she should have been able to carry sail through it all, and at such tremendous speed, is quite astonishing. The courage and skill of Captain Harvey and his able coadjutor, Captain Nicholson, an officer in the army, were admirably displayed in starting again from Truro after encountering such a gale of wind as they had in skirting the

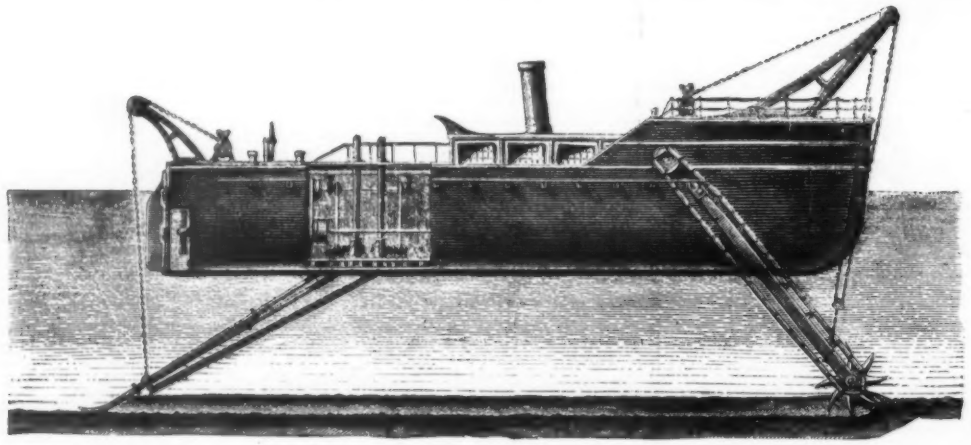
Bay of Biscay from south to north. One member of the crew—who were all volunteers—was the boatswain of the unfortunate Teuton, wrecked at the Cape last year. This man expressed his wish to join the party in order to prove that it was no fault of the Berthon boat on board the Teuton that it did not save the passengers. His testimony on this point concurs with that of all the other survivors, that the said boat was never lowered nor opened at all, but like others of the boats went down with the ship. The total distance run on this occasion could not have been much less than 800 miles, and when it is considered that the whole time she bore the brunt of the gale which raged here in the beginning of last week, we have abundant proof that the Berthon boats are not exceeded in seaworthiness and speed by any others in the world. The boat is now afloat in the inner dock at Southampton, and has not suffered in the smallest degree. She has been visited by a great many members of the British Association. The dimensions of the boat are as follows: Length, 28 ft. 4 in.; breadth, 8 ft. 6 in.; depth 3 ft. 9 in. When shut against the bulwarks of a ship her width is 22 in. with all her gear stowed in her, such as masts, sails, oars, water breakers, and anchors. The time required to open, set up, and lower such a boat is less than one minute. It was done before 160 members of the British Association in forty-five seconds. It is an interesting question whether the great elasticity of these boats has not something to do with their unusual speed. For illustrations and further description of this boat see Scientific American Supplement, Number 341, July 15, 1882.

BAZIN'S SUBMARINE EXCAVATOR.

The accompanying cuts represent a system of dredging devised by M. Bazin, a French engineer well known for his numerous and remarkable works. This system has been employed with success in France, Spain, Russia, America, and, recently, in England. The Bazin apparatus partakes at once of the nature of the sand-pump and hydraulic ram. Its principle consists in the fact of creating, while utilizing the difference in density between liquids, an artificial fall of water, whose live-power carries along the earthy or sandy materials diluted to a density that should not exceed 1·30. A movable pipe that traverses the boat rests on the material (sand, mud, or disintegrated earth) that forms the bottom. Supposing the bottom at a depth of 10 meters under the boat, and 1·25 to be the mean density of the material to be removed, the latter will be carried along by the current of water and raised to a height of 8 meters with a velocity uniformly retarded by the friction experienced along the pipe. It is just here that there intervenes a theory absolutely peculiar to this apparatus, and that deserves to be mentioned. Under the action of the column of water pressing against its orifice, the muddy liquid rushes into the pipe with a certain velocity to empty into the interior of the boat. Before such velocity is entirely destroyed by friction, let us interpose any expelling apparatus whatever—pump, ejector, or cock. The problem will be reduced to a calculation of such apparatus so as to expel in a definite direction the materials thrown against it, *without sucking them up*, and consequently without any harm to its mechanical parts. M. Bazin makes use of a centrifugal pump, whose maximum forcing action takes place with materials possessing a velocity of 3 to 4 meters per second. It is only a question, then, of placing this pump in the inside of the boat at such a point that the velocity of the current in the suction-pipe, reduced by friction, shall be perceptibly equal to that of the materials expelled in the force-pipe for the maximum discharge of the pump. There is thus an equilibrium of the two sides of the pump's buckets, and consequently a reduction of mechanical losses to a minimum.

Operation of the Bazin Dredge.—The dredging boat of this system is provided in front with an excavator, by means of which the bottom is disintegrated, and which receives its rotary motion through the intermedium of a pitch chain. In the back of the boat are located the suction-pipes, which terminate at pumps designed, as we have seen, only for throwing to a distance the materials that issue from the pipes. Each of these latter is provided at the bottom with a rose to prevent the entrance of too coarse materials, and carries laterally a slit to permit access of water, so that when the pipe happens to choke up, a lateral current flows in, dilutes the materials, and gives them the density proper to permit of their evacuation. It is evidently necessary that the apparatus shall be able to work at varying depths. For this reason, that part of the pipe that enters the hull is of thick, but flexible India-rubber, so as to permit of the suction taking different inclinations. Such inclination is regulated by a workman by means of a crane. When the liquid issues too clear he lowers the pipe, and when it is too greatly charged with solid materials in suspension, he raises it. This maneuver, on the excellence of which depends the discharge in great measure, demands but little practice on the part of the laborer. The choice of pump employed for expelling the materials is not without importance. The inventor makes use of well regulated centrifugal pumps that do not wear greatly in such service, owing to the fact of the equilibrium in pressures at suction and forcing which makes them, after a manner, operate in a homogeneous medium.—*Le Genie Civil.*





BAZIN'S SUBMARINE EXCAVATOR.

ON A NEW SYSTEM OF HYDRAULIC PROPULSION.

By Vice-Admiral J. H. Selwyn.*

The subject to which I am about to draw your attention is one of considerable interest, not only on account of its connection with hydraulic propulsion, but as leading to the study of a hitherto neglected branch of hydrodynamics, which may even influence, when thoroughly understood, some of the accepted physical theories.

We are all more or less familiar with the various forms in which machines for utilizing water-power have been made. In useful effect produced, no doubt the turbine stands at the head of the list, and the attempts hitherto made to apply hydraulic propulsion to vessels have almost invariably comprised some form of turbine, to which the power of the engine was applied, in order to obtain a reactive effect from water set in motion. But in every one of these systems, not excluding the most modern form of centrifugal pump, the methods employed were such as to produce the following effects:

First, the water was set in motion by disks, fans, vanes, paddles, or screws, inside a casing, which confined it, so as to produce a pressure.

Next, the water under such pressure was caused to take a determinate direction.

Lastly, a controllable ultimate direction was imparted to the water, which might be forward, backward, or opposite on the two sides, or, again, entirely annulled by being converted into upward pressure, at the will of the operator, and without interfering with the movement of the engines.

It was, in fact, the realization of a most perfect form of propulsion, which, being entirely based on reactive effect, was not, and could not be, dependent, like the paddle and screw, on the steadiness of the vessel for its maximum useful effect, besides presenting many other advantages which have been often brought to the notice of this institution, and which it would be out of place to bring forward again on this occasion.

But there have been also objections made to the use of hydraulic propulsion, and these have been invariably on the score of lower speed obtained with a given I.H.P., since nothing else could have been adduced against a system which on all other points showed so unmistakable a superiority. No impartial observer will allow, if he is fully in possession of the facts, that any such defect in speed has been shown, but the objection still has great weight with large numbers of persons who ought to be better informed on a matter so nearly affecting the maritime interests of Great Britain.

But we will, if you please, for a moment consider what the objection would amount to, were it absolutely true. More I.H.P., and therefore more fuel must be used; but this would be all, and with more economical modes of burning fuel and less of the "baseless superstitions of the profession" (as a great American engineering authority has called them) as to the pressure at which we use steam, this increase of fuel expenditure might be nullified. Would this be the case with the paddle and the screw? Clearly the question must be answered in the negative, for both being dependent on the area of water against which they push for their reactive effect, and this area being limited constantly by the draught of water of the vessel to which they are applied, and occasionally by her movements in pitching and rolling, can never be equally efficient with the internal reactive effect produced by a properly constructed hydraulic propeller. The problem involved in the construction of such an instrument is much more complex than would at first sight appear probable, and we shall find that one of the first conditions of success is, that all change in the direction of the water when set in motion by the machine, which is not necessary for our purposes, is to be sedulously avoided. Next, that all lifting of a column of water detracts from the propulsive effect, since whatever power is absorbed for this purpose is taken from that which is available for setting the water in motion in a direction contrary to the path of the vessel, and it is from this source that we expect our forward motion. Thus the water ought to be taken into the vessel when moving with the least possible effort, and leave it with the least possible shock.

Theoretically, therefore, the water should enter the bottom of the vessel by its own gravity, should ascend an inclined tube forming part of the vertically disposed propeller casing, and having had motion imparted to it by the propeller, should leave the vessel immediately above water, with the velocity and area necessary to overcome the resistance of the vessel, and to give her the desired speed. But there should be no whirling or vortex action of the water, and no changes of cross-sections or bends in the tube, since

* From the "Journal of the Royal United Service Institution."

all these tend to diminish the ultimate velocity with which the water leaves the vessel, and *v* being velocity in feet per second, pressure in pounds on the square foot is $v^2 \times 0{\cdot}976$, but little less than the square of the velocity itself.

In the Waterwitch I find—

Area of orifices of discharge, 6 square feet;

Velocity of water of discharge, 30 feet per second;

and by the foregoing formula, 878·4 lb. per square foot, which gives for 6 square feet 5,268 lb.

Now it may fairly be said that all those hydraulic propellers we have hitherto seen applied, have the features which I have referred to as being theoretically objectionable very strongly developed. They do interrupt the motion, they do create vortices, and they have contractions and bends in the channels of the water. They also develop a pressure in the casing, due to these circumstances, which, though it may be, nay is, indispensable in a pump or a revolution indicator like Mr. Tower's, is positively to be avoided in a propeller.

Yet, in spite of all these defects, the hydraulic propeller has given a speed of vessel equal to that of the screw, under, as nearly as possible, similar conditions.

It is also to be remarked, that it has never yet been tried under those conditions of high velocity which would be most favorable to its action and most fatal to that of the screw, unless we are to admit unlimited draught of water or a reduplication, which I should consider most unobjectionable, if the effect we seek can be got without it.

Having thus glanced at the merits and defects of known systems of propulsion, I propose to bring before you the invention of Mr. George Wilson, C.E., who is the author of papers on the "Flow of Gaseous Substances into each other at High Pressures," and who has, in Holland, had extensive experience in the use of Gwynne's and other centrifugal pumps.

I said at the commencement that I was about to refer to a neglected branch of hydrodynamics. It is this: That water (indeed every fluid or gaseous body) adheres to solids with a force proportioned to the square of the velocity with which the solid passes through it. Now, there are many familiar instances in which this effect is seen. If a grindstone be driven fast in a trough filled with water, not only is the water centrifugally dispersed, but a film of water will be seen ascending higher and growing thicker on the periphery as the speed is increased. If a fly-wheel pit be filled with water, the rim of the wheel, though turned smooth, and more, the smoother it is, will instantly do as the grindstone did. If again, a circular saw be drowned in water, it will empty its own pit. A ship also carries, as we know, a skin of water with her. Neither has the principle been left without its application in pumps, for Messrs. Gwynne's pumps have been most successful since the internal wheel took the shape of a disk, on which the blades of the former turbine remain only as mere adjuncts. In propellers, too, Mr. Aston's paddle-wheels, which had no paddles, but only rims, are an application of the same principle.

But none of these are capable of perfectly fulfilling the conditions which ought to be obtained for the propulsion of vessels with convenience and economy, the rim paddle because of the position and size, the centrifugal pump because it creates a vortex, and all modifications of paddles revolving in cases because they create counter-currents which impede instead of assisting the water in a determinate direction.

You will, perhaps, be surprised to hear that a common grooved pulley, differing from the sheave of a block only in size and shape of groove, has been found capable of doing what is wanted without any of these impediments, and that the smoother the pulley, the better the effect produced.

The size of pulley, or diameter, is dependent upon the circumstances of the particular vessel that has to be moved and the velocity with which it is sought to move her; but it may generally be said, that in light draught vessels a small wheel with a high velocity will be found most convenient, and in deep draught vessels a large wheel with less speed of piston; and this suits well with other requirements, since, while we have been able to drive small engines at very high speeds, it is difficult, *with any reciprocating system of engine*, to obtain high velocity without serious strains, when great weights are employed.

To give some practical idea of the machine proposed, we will take two types of vessel, one of light, the other of deep draught, and show the calculation. "A" is a vessel whose draught of water is 4 feet, her mid section 80 square feet, and her wetted surface 2,000 square feet.

The diameter of each of two pulleys, applied on the main shaft of engine (which is fixed transversely, and has a speed of 300 revolutions per minute), is 4 feet 6 inches, therefore roughly the circumference is 13 feet 6 inches. This pulley is 30 inches wide, and has in it a parabolic groove 15 inches deep. Half of this depth has to be deducted to arrive at the mean active periphery. The pulley will therefore be calculated as being 3 feet 3 inches in diameter, and 9·9 in circumference: $9{\cdot}75 \times 300 = 2{,}925$ feet per minute, about 48 feet per second.

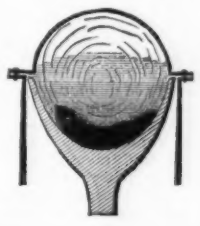
The Waterwitch attained a speed of 9 knots or 15·21 feet per second, with a velocity of 30 feet per second, and the effect is known to increase as the square of the velocity, so that if our area is sufficient we ought to get with 48 feet per second a speed of ship of about 14 knots, unless the resistance due to form is greater than in the Waterwitch. Now, let us see what area we have, and how many pounds pressure on that area.

The area of the parabola is two-thirds of that of an equal square. We have here 30 inches $\times$ 15 = 450, two thirds of which is 300: area is therefore 300 square inches. As before $v^2 \times 0{\cdot}976$ is pounds pressure per square foot, and amounts to 2,247 lb., which multiplied by 2, the square feet in area, gives 4,494 lb. as the pressure exerted at each pulley (roughly about 2 tons). We know that with the paddle and screw, from numerous independent experiments and experimenters, the tractive force due to 100 I.H.P. is about 2 tons.

We also know that 0·301 of an I.H.P. per square foot of wetted surface will drive an ordinary ironclad 15 knots with twin screw. Further, that 3 I.H.P. per square foot of mid section is a fair allowance for 12 knots. I might say a very full allowance if it be effective horse power. With these data it becomes easy to calculate what horse power the engines should exert to drive such a vessel at any given speed, remembering always that with such an instrument as this all increase of power in the engines will constantly be felt as increase of propulsive effort, in the proportion of the squares of the increased velocity.

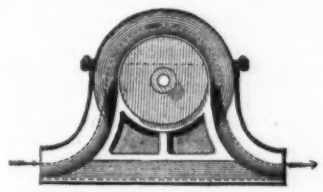
We will now take the calculation for the deep draught ship, say 22 feet draught, with the usual proportions for a fast vessel in other respects, but limiting ourselves to 70 revolutions of the engines, and a single engine, not two or more, which might evidently be used if preferred. "B," then, will have two pulleys, or wheels, on each side, of which the external diameter will be 20 feet, the groove 3 feet wide, and the depth of groove 18 inches, with 70 revolutions, the velocity will be 59 feet per second and the speed of ship about 17 knots, if there be sufficient area. The area will be 864 square inches, and the pressure per square foot 3,397 lb. $\times 6 = 20{,}382$ lb. on each of the two jets. But 20,382 lb. is only equal to a little over 9 tons, and as with such a ship we should employ about 3,000 I.H.P., each hundred of which would give a pull of 2 tons, or 60 in all, it is clear that the above area will be entirely insufficient for our purpose. We want at least three times as much, or six such pulleys on each side. That is about 18 feet of pulleys in the thickness on each side of the engine, which would be absurd. Now suppose we can increase the number of revolutions of the engine to 140 without difficulty, and I am disposed to think this might be done, what help should we get in that direction? The velocity would rise to 118 feet per second, and 118^2 gives 13,924, say 6 tons per square foot. Now we have 6 square feet in each jet and 6 tons pressure per square foot, so we should have 72 tons pressure in all, or more than we require as the result of 3,000 I.H.P. So that there is no insuperable difficulty in the application even in what must be regarded as an extreme case, for if the engines were duplex, as in twin screws, it would be easier to attain the results, and there would be some other advantages gained in the event of one engine breaking down, or where rapid turning power was required.

It is also possible to increase the area of groove by making the casing which must always surround the pulleys in a parabolic or circular form, so that the cross-section of any part of the groove will be parabolic in the groove and semi-circular in the casing, and this will very likely be found to



be the most perfect form, particularly at very high velocities, where the water may almost be considered as a rope passing through the vessel, by which she is dragged along, much as a railway engine drags itself and its load along a rail.

Hitherto, I have only spoken of the pulley or wheel, but you will see by the models and drawings that there is another very important feature. The water only enters on the wheel and leaves it at the semi-diameter, because this is the limit of the useful motion that can be imparted or communicated. All beyond the semi-diameter, whether the water be conducted over or under the wheel, though useful in a pump, would be dead loss in a propeller. To meet this condition there is introduced a species of diaphragm of peculiar shape and section fitting nearly the lower part of the groove, and having curved surfaces, which form a continuation of the limits of what has been called the "rope of water," which form in fact with the casing a pipe through which that rope of water passes. It will easily be seen that the tendency of water set in motion by any portion of the periphery of a wheel, and prevented from flying off centrifugally, would be to follow the periphery in its circular path, as in the helical pump, the disk pump, and all centrifugal pumps pure and simple. But with the condition of propulsion to fulfill, the energy must be directed in another path, namely, that which is opposite to the progress of the vessel, and in this machine it is done by, so to speak, scraping the water off the wheel, and diverting its motion into the needed curve. In doing this there must necessarily be a slight loss of power, but it is the least possible, consistently with the effect to be produced. The path of the water is shown by the arrows and dotted line in No. 2 diagram.



Arrangements are made by which the reversal or interruption of the motion can be effected, while the engines continue to exert their full speed ahead something in the same way as in the Waterwitch.

I have now put before you the shape of the instrument proposed and given you some account of the way in which it does its work theoretically. But this latter would be incomplete were we not to examine the question of hydrodynamics involved. In Mr. Scott Russell's paper (vol. xxii., No. cii., of the Journal of this Institution), are some statements which show very clearly how water is acted on by wind. Here is a case, not of a solid body imparting motion to water confined in a casing, but of water set in motion by the impact of the atmosphere, the direct pressure of which is, according to Mr. Scott Russell:

1 lb.	for wind at	20	miles	per hour.
4 lb.	"	40	"	"
9 lb.	"	60	"	"

Query, what is the pressure to be added on account of direct weight of atmosphere.

He says also, that 4 lb., or the sixteenth part of the weight of a cubic foot of salt water, could communicate a velocity of 2 feet per second to 1 foot of water in one second of time.

These statements will serve to show what we might expect from such a pulley as I have been describing, set in motion at such a speed in a body of water. From another paper on *Tower's Revolution Indicator* (vol. xxiv., No. cv.), we find that in that instrument, which is a paddle turbine, raising water in a confined column to a height corresponding to the number of revolutions, the elevation of the column is precisely that due to the number of rotations, multiplied by the *external*, not the *mean* circumference of the wheel, and calculated according to the laws of falling bodies. Therefore, even at the comparatively slow speed of 60 or 70 revolutions, we might be sure that the whole of the water is really set in motion, since the atoms must react on each other precisely as they do when wave motion is produced by wind, with the remarkable difference, however, that the motion is propagated from the motor outward, not from the surface inward, and thus in some measure resembles the wave of translation, which delivers its force through any distance without diminution. It is now necessary that I should tell you what has actually been done in practice. Engineers of high standing had predicted utter failure. They said that it was absurd to suppose that a smooth pulley could communicate any motion to water. It ought at least to be roughened, if it did not require paddles; this was disproved *in a bucket*. Then "it might move water in that way, but it could never act as a pump;" this was disproved in a tank. Then it could, at least, never answer as a propeller; this has been disproved in a boat. I have not the least doubt that it will now pass into the second phase of inventions. The first is, "the thing is not good;" the second is, "the thing is not new." After these are disposed of there will, no doubt, come some other phases of the subject, which are principally disguised attempts to appropriate the profits; and I can only say, though I have no other than a scientific interest in the question, that I hope the inventor will get his reward in due time, and not be left to languish like "Screw" Smith, and so many others of our cleverest inventors. At the beginning of this paper I spoke of the subject being an interesting one from purely physical points of view, and I wish briefly to call your attention to this part of the subject. If we admit that the adhesion of water to a solid moving in it is so great that the whole velocity of the moving body can be imparted to it, we shall first see the importance of skin friction in ships, and be able, perhaps, to measure it more accurately. We shall be able to find out the value of the same force acting on the surface of our screws; we shall be led to reconsider the whole problem of pumping the engines at high speeds (the account of the work done by a centrifugal pump at Crossness shows the necessity of this), and generally there will be a new light thrown on many most interesting problems in hydrodynamics.

But we may go even further, I conceive, and examine into the great forces at work on the globe, either to retain the water of the ocean in its place against the centrifugal force, or to cause the motion of great bodies of water from east to west. What may not be due to a speed of a quarter of a mile per second, if with the petty speed of under 100 feet per second, such results in propulsion may be produced. I venture to commend the whole subject to the younger members of the naval profession as one full of interest for them, but there is matter enough for thought in it for engineers and philosophers of the very highest caliber, and by these I hope it will be taken up and thoroughly investigated. I believe we shall find a law prevailing that speed of rotation being a quarter of a mile per second, adhesion is absolute. Finally, I have only to say that when a vessel of about 130 tons now preparing is completed, I shall be happy to give a more complete account of the advantages of this mode of propulsion, combined with the Perkins engines of 200 I.H.P. This I hope to be able to do some time in the autumn of this year.

THE ST. GOTHARD TUNNEL.

Report by S. H. M. BYERS, United States Consul, Zurich, Switzerland.

THE recent opening of the St. Gothard Railway through the Alps to Italy represents the completion of what is perhaps the most stupendous work of engineering known to the world.

What the ultimate effects of this short road to Italy may be on the commerce of Europe it is too early yet to calculate. The immediate prospect, however, is that the methods of trade as between Germany, Switzerland, Italy, and part of France will, in a sense, experience a revolution.

Before the completion of the tunnel I was permitted by the chief engineer to examine the methods of work and the machinery in use, and to know something of the estimates of costs, etc., concerning which I wrote at the time.

The full completion of the railway, however, and its opening to travel and trade offer opportunity of showing *facts*, instead of mere estimates, as to the enormous expense of the work, the time required in building, and some of the immediate results.

The St. Gothard Pass is many centuries old, and is over a chain of mountains the highest in Europe, though not showing the highest single peaks. In the snow-fields, almost immediately above the new tunnel, rise the principal rivers of Switzerland flowing north and south, the Reuss, the Picino, the historic Rhone, and the classic Rhine.

The scenery along the route of the pass is of sublime grandeur. The very top of the pass is a little plateau or valley, a few miles in length, surrounded by dreary rocks, with mighty peaks and snow-fields in the near distance. It is silent and desolate, and, with the single exception of the old stone hospice, no signs of human life or marks of human hand are to be seen. The height of the old post road in this little valley is 7,000 feet above the sea. Some of the peaks in view are 9,000 to 10,000 feet in height. For centuries this mighty mass of mountains has stood as a barrier between the north of Europe and the sunny lands of Italy. The old Helvetians, under Orgetorix or Diviko, had not greater longings for an easy way to the warm southland than the Europeans of modern civilization have had.

Before the building of railroads it was a journey of weeks to travel around the higher Alps into Italy from Switzerland. A foot-path was made over the St. Gothard from the valley of the Reuss as early as the beginning of the thirteenth century, but it remained a dangerous and dizzy foot-path only. It was only a hundred years ago that the first vehicle of any kind was dragged along this foot-path over the Alps.

In 1820 the Canton Uri, aided by the confederacy, commenced building a post-road along this mountain path, and at an expense that was something enormous, considering the time, the smallness of the population, and their poverty. The road was, like all Alpine post-roads, a specimen of bold engineering. It crossed tremendous gorges, clung in dizzy places to the steep sides of high mountains, swept around sudden corners and angles, and reached heights above those of any previous mountain road. Its novelty and the grand pictures of the route soon made it a chosen way to Italy for tourists, while the commerce of Switzerland changed its whole course. This post-road was 18½ feet wide, and had an average grade of 10 per cent. At points where avalanches threatened it, it was bridged or roofed over, and the

great masses of snow and ice rolled by, leaving the road, the mountain diligences, and their traveling occupants unharmed As a mountain-pass post-road the St. Gothard was and is unexcelled; but modern inventions, greater progress, and unheard of travel have combined to make a shorter route to Italy a necessity. Man could not go *over* the Alps by shorter ways, but he could go *through* them.

The idea of piercing the St. Gothard chain of mountains is as old as railroads in Switzerland. Engineers in Switzerland have lived and died with the one great thought of connecting the cold north with the sunny south by iron rails through the mountains.

The first railroad built in the country was opened in August of 1846. It was the line from Baden to Zurich, and the proposal was even then made to ask concessions to enable the company to continue its lines into the mountains of the Grisons and over one of the high passes. The rivalry of other companies, the jealousy of different cantons and towns, and the want of government aid all conspired to postpone and defeat a measure wished for by the whole people.

The history of the thousand obstacles to overcome before a route and plan were determined upon would here be neither interesting nor profitable. Suffice it to say that the question of building the St. Gothard road became a vital one to the whole people, and at last a *political* one, and one not only national but international in its character. After endless jealousies and intrigues on the part of individuals, of companies, of towns, and cantons, a society or union was brought about in the year 1863. The cost of the great work was estimated at 187,000,000 francs, a sum too great to be risked by private capitalists alone.

In 1869 the Prussian Chambers signified an intention of helping to build the road by a suitable subvention. Baden and Wurtemberg also promised substantial aid, and by 1871 (after the conclusion of the Franco-German war), a promise of important subventions to the scheme was agreed upon by treaty on the part of the Swiss Diet and the German and Italian Parliaments. In this treaty Switzerland agreed to pay 20,0 0,000 francs to the scheme, Italy promised 45,000,000, and Germany 20,000,000 francs, and the Swiss Government undertook to supervise the work. On the 6th of December, 1871, the company of the St. Gothard Railway was organized at Lucerne, with Dr. Alfred Escher as president. The company issued stock to the amount of 34,0.0,000 francs in £20 shares, and 68,000,000 francs in mortgage bonds.

The contract for the great tunnel was undertaken by L. Favre, of Geneva, supported by a company of well-known capitalists. He agreed to complete the work in eight years, forfeiting large sums of money for every single day's delay in the final completion. The work commenced on the north side of the Alps on the 4th of June, 1872, and at Airolo, on the south side, on July 2 of the same year. The undertaking was not more than fully under way when it was discovered that a tremendous mistake had been made in the estimates; it was found that the work would cost, if continued as projected, not 187,000,000 francs only, but 289,000,000; hence, a deficit liable to be on hands of 102,000,000 francs. Then came the crisis in the history of the road. All sorts of bad results followed immediately. The stock of the company ran down to a minimum, and hundreds of families were nearly ruined by the collapse. The bonds shared in the crash; and even the most ardent friends of the enterprise feared that the money which had been so lavishly given was buried under the mountains for ever. It became a question whether the work would not have to be abandoned. There was but one choice, either to lose all that had been done or to add many millions more to the subvention. The times were very hard. Financial crises were imminent everywhere; and, to add to the threatening calamity, war was raging on the continent. Everybody was discouraged. Some of the little cantons of Switzerland, the very ones that expected the most benefit from the enterprise, refused to lift a hand or to spend another dollar.

In the face of all opposition, however, and after surmounting many new obstacles, additional capital for the prosecution of the enterprise was secured. Some of the approaches to the great tunnels were abandoned, for the time reducing the expense. Germany, Switzerland, and Italy added largely to their promised subventions, while leading Swiss railways and cities voted sums of money in proportion to the benefit they hoped to reap.

The work on the tunnels during this financial crisis of the undertaking had never quite stopped. Any unusual delay, in fact, would have proved ruinous to the contractor, Mr. Favre, as his agreement was to forfeit $1,000 for every single day the work might fall short of completion at the time stipulated. Should the delay extend to six months beyond the stipulated time (October 1, 188), the forfeit was to be $2,000 per day.

On the other hand, $1 000 per day was to be paid to Mr. Favre for every day the work should be completed in advance of the time stipulated. Unfortunately, Mr. Favre died when the work was scarcely half done. Had he lived, and had Swiss jealousy not driven Mr. Hellwag, a celebrated German railway builder and the chief engineer of the Gothard enterprise, from his post, the St. Gothard and its tunnels would, in all probability, have been completed within the time contemplated.

A brief description of the road and tunnels will indicate what an enormous work it was that the St. Gothard Company, Favre and his confrères, undertook to build through the granite and under the snow fields of the Alps.

The Gothard Railway proper extends from Immensee in Switzerland, to Chiasso in Italy, a distance of 113 miles. There are, in all, not less than fifty-six tunnels, comprising more than one-fifth of the whole line. Many of these tunnels are constructed in spirals to enable the road to make very great ascents within short distances. These spiral tunnels were the invention of Mr. Hellwag, the chief engineer. There are, besides those wonderful and difficult tunnels, many lofty viaducts, bridges, and complicated galleries. The main tunnel is 9¼ miles long, and others exceed 6,000 feet in length. There are, in fact, 23 miles of tunneling on this short line. The width of the great tunnel is 26 feet, and the height nearly 19 feet. At Airolo it is 3,756 feet above the sea. At Gaschenen, on the Swiss side, the elevation is 3,638 feet above the sea. The strata through which it was necessary to pierce the great tunnel was estimated in advance as follows:

Commencing at the Swiss end—

	Feet.
Granitic gneiss	7,000
Schistous gneiss lying vertically in ledges	1,000
Crystalline limestone with streaks of black serpentine	500
Micaceous schist	3,000
Gneiss rich in mica	20,000
Schistous gneiss with quartz	5,000
Mica schist	12,000

With exceptions of certain reaches of soft clay, almost impossible to roof, on the Italian side, the advance estimates of geologists proved very nearly correct.

The improved boring-machines used for drilling the tunnel were driven by compressed air, produced by immense Gerard turbines. These turbines were driven by the rapid river Reuss. The compressed air was conducted from the compressors outside to the boring-machines in the tunnel through iron tubes 6 inches in diameter. This air, escaping from the machines as they worked the drills against the face of the rock, served to ventilate the tunnel. At the north end of the tunnel the turbines delivered into the reservoirs over 3,500,000 cubic feet of compressed air daily, which, escaping at the drills, pushed back and out of the tunnel some 210,000 cubic feet, daily, of bad gases and smoke. In spite of the escaping air, however, the ventilation of the tunnel remained bad. It was not the natural gases of the tunnel only, nor the presence of thousands of workmen and animals, but the hourly explosions of dynamite used in blasting, that made the tunnel almost unendurable at times. There were some fifty air-drills at work in each end of the tunnel constantly, being operated at seven points of attack; that is, in the main heading, and at points right and left further back, as well as on banks of rock behind, that were left when pushing the gallery forward. The main heading was worked on the Belgian system, viz.: boring a hole some 8 feet square, in advance, where the top of the tunnel was to be made. Often, too, this advanced gallery was finished up and arched before the bottom and sides of the tunnel were commenced or even excavated. The complete arch was usually put in in sections of 18 feet, and was always allowed a few days to settle before other sections were joined on. The advance made in the galleries at the heads of the two tunnels approaching each other (parties worked from both the Italian and Swiss sides) was usually about 21 feet for the two sides per day. The whole structure, as fast as excavated, was lined with a circular wall, or tube, of masonry 18 to 30 inches in thickness.

The work was done principally by Italians. No other workmen would accept so much toil and danger for so little pay. Hundreds, possibly thousands, of these Italian workmen have been stricken down with diseases produced wholly by the bad air of the tunnel They worked eight hours per day, receiving from 3 to 6 francs a day and boarding themselves. Of course the greater number received 3 francs only. They saved part of their wages, however, and sent it home to their needy families in Italy. Their food was extremely limited in quantity and wretched in quality. It consisted usually of nothing but *polenta*, or some meal porridge. The statistics show that 310 of these Italian workmen were killed by accident during the building of the tunnel, and 877 were wounded or received minor injuries.

The final cost of building the St. Gothard Railway and Tunnel, in accordance with modified forms, is now reported at something over 200,000,000 francs, not including the rolling-stock and material for working the road.

On the 22d day of May, 1882, about ten years after the commencement of the tunnel, the festivities began in Luzerne in honor of its completion. These festivities were on a magnificent scale, including banquets, excursions, fireworks, etc. They extended through several days, every town on the line from Luzerne to Milan being in gala-day attire. They were attended by high official representatives of the German Empire, of the Kingdom of Italy, and of the Swiss Republic.

Passenger trains at once commenced running, and the tourist and goods traffic has already assumed immense proportions. The distance from Germany and North Europe has been lessened by at least thirty-six hours, while the conveniences and advantages to trade and travel by this Alpine line are almost beyond calculation.

What the political results of the completion of the enterprise may be must at present remain a matter of conjecture only. That new jealousies will be awakened, and new political combinations be determined upon, there can be little doubt. Already political writers are busy with the possibilities awaiting Swiss neutrality and independence in case of a European war.

The tunnel will make a movement of troops from Germany in the north to Italy in the south a matter of such rapid and easy accomplishment that France may easily fear alliances not to her advantage; and, seeking to compel a neutrality of the tunnel route and Switzerland, drive the latter into choosing sides with open enemies, at the risk of losing all in contests not of her own making.

Those who believe progress and rapid communication to be aiders of peace see nothing but friendship and closer unity of nations in the great Alpine highway. English opinion—at least whatever the *Saturday Review* may represent of English opinion—sees in the building of the St. Gothard road the reverse of peaceful results. "It would be idle to conceal the fact," says the *Saturday Review*, "that this St. Gothard Tunnel has been conceived, carried out, and opened in a thoroughly bellicose and aggressive spirit. It is openly given out as a blow to France, not merely commercially but politically." The *Review* points out in detail the tremendous advantages this tunnel may give Germany, with Italy as an ally, in case of war with France. It ridicules the complacency of the Swiss in rapturously applauding the unusual embracing of the representatives of Germany and Italy, and boldly asserts that "the patriotic Swiss might read between the lines of Herr von Kendell's blandishments a suggestion that Switzerland ought to be either *Italian* or *German*."

Though speaking from an English, and a comparatively disinterested standpoint, the *Review* forgets, apparently, that with the Swiss neutrality as to European wars and patriotism are near akin. Swiss neutrality, unless forced, is as old as Swiss independence, and is, by Swiss leaders, considered the only sure guarantee of continued independence. The *Saturday Review* overlooks, too, the seldom concealed sympathy felt by most Swiss for France and for French institutions, as well as the more material fact that France is herself expecting within a reasonable time to have an Alpine tunnel of her own into Italy *via* the Simplon Pass. A tunnel, too, on the route of the Luckmanier Pass, from southeast Switzerland, is seriously contemplated, and national aid has been promised.

These additional routes will lessen the importance of the St. Gothard as a line of trade and travel, and, together with Swiss love of independence, would create obstacles for German war strategists that even an unnatural Italian alliance could not overcome.

THE deepest mine in the world, according to Prof. H. Hoefer is the Przibram silver mine in Bohemia. The lowest depth is nearly 3 300 feet below the surface. At this depth the temperature of the rocks is only 75 00° F.; and the temperature of the air 76·3° F.

STRAW LUMBER.

FROM time to time more or less has been said about the manufacture of straw lumber, a material likely to come into use as a substitute for wood. About two years ago, as set forth in the *N. W. Lumberman* at the time, Mr. S. H. Hamilton, of Lawrence, Kansas, began the manufacture of straw boards by a process by him invented and patented, and the results were watched with considerable interest. This gentleman, however, was so unfortunate, it will be remembered, as to have his establishment, which was limited in extent, burned at about the point when his machinery was in good working order. Something over 1,000 feet of straw lumber had been made when the fire occurred, and was mostly scattered among interested parties as samples. Though this product was necessarily imperfect, as the result of early efforts largely experimental, it was found to be a most valuable invention, and in many ways capable of taking the place of ordinary lumber.

But since that time little that was definite has been said about the enterprise, except in a local way, and it has been a subject of conjecture as to whether the disaster met with had put an effectual quietus upon further operations in that direction. Such was not the case, however Some little time afterward the patentee succeeded in getting men of capital interested in the matter, who, being practical men, were readily impressed with the importance of the industry. The overtures made resulted in the formation of the Hamilton Straw Lumber Company, with the following officers: S. H. Hamilton, president; C. W. Hilliard, vice-president; F. C. Clark, secretary. Mr. Hilliard is a Chicago gentleman, and two other prominent Garden City representatives are stockholders, namely, H. H. Porter, president of the Chicago, St. Paul, Minneapolis and Omaha Railway, and R. R. Cable, vice-president of the Chicago, Rock Island and Pacific Road.

The company began operations in a preliminary way, with a capital of about $25,000. A new mill was built at Lawrence this year, which was gotten under headway in May. After running about a week it was ascertained that the steam presses were inadequate, and new ones of greater power were put in. After some little delay operations were resumed, and the mill is now in thorough working order, and turning out a limited supply of a remarkable product. The mill is 36 ft. x 150 ft. in extent, and the storehouse for drying the straw lumber is 25 ft. x 50 ft. The machinery is, in the main, constructed especially for the purpose, but a part of it is in some respects similar to that commonly used in paper making. All kinds of straw are used, the raw material being first made up into pulp by the ordinary process, and then rolled into thin sheets, about twenty-four of which would make an inch in thickness. While wet and hot, and in a condition to readily absorb liquids, these sheets are passed through a vat of chemicals heated to 280 degrees Fahrenheit, the excessive temperature being sufficient to scald the liquid into the sheets till they have become thoroughly impregnated with the chemicals, wherein lies the great secret of preparation, and by which satisfactory results are secured. After this the sheets pass through ten pairs of polished iron rollers, drawn so closely to each other by means of powerful steam-pressure that the space between them is not perceptible. The sheets are forced through apertures which apparently do not exist. Cement is applied by the operation of mechanism to which a system of brushes is affixed, and a further pressure is applied, ultimately resulting in the production of a hard and firm substance comparatively fire-proof.

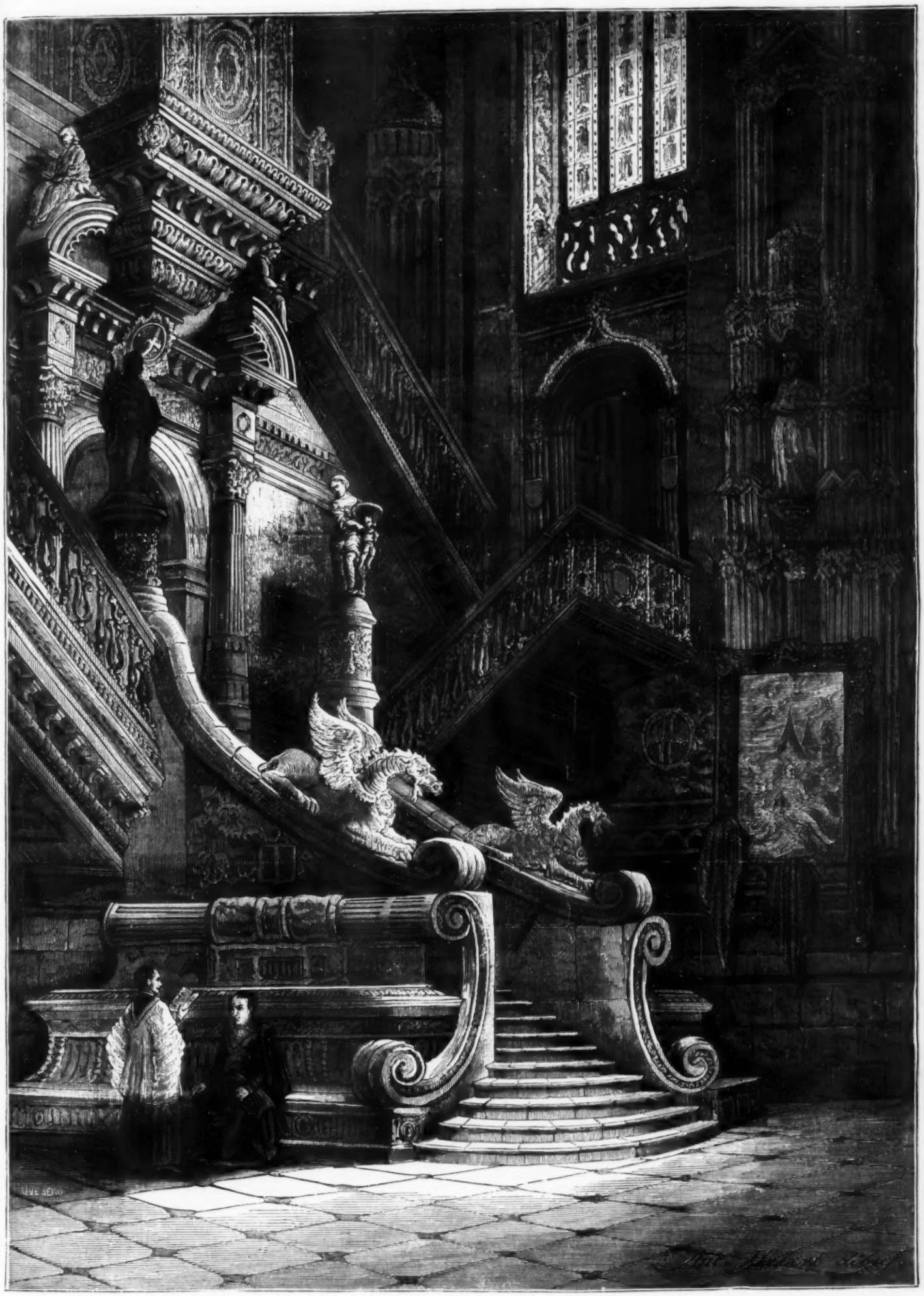
After being made the lumber must be permitted to dry thoroughly, which requires from a week to a month. A storehouse free from dampness is required. Kiln drying probably would not answer. If used before it is dry the lumber will warp, but will not when dry, which fact has been demonstrated by use. So far the lumber has been made principally into flooring, ceiling, blackboard strips, and friction-wheels. The present machinery can only turn out boards of different thicknesses, thirteen feet long and three feet wide, which can be sawed into any shape, the same as common lumber. The boards cannot be split into less thicknesses, but must be made the right thickness for the use intended. More extensive machinery could be had, so that the lumber could be made any length, width, or thickness likely to be desired in any practical use. While the capabilities of the straw lumber, when fully perfected, seem limitless, the manufacturers make no extravagant claims for it, only seeking to have it applied to the more simple and practical wants till experience and results shall extend its sphere.

All that the *Lumberman* can say for the material will be to present the facts given as a result of the application and tests that have been made of it so far, for time will best prove its merits. When finished it looks what it is--a slab made out of straw. The surface has an appearance of unevenness which is deceptive, for while it looks rough it is found to be smooth. The materials and fibers of which it is composed give it a streaky appearance. It is very hard, compact, and firm, saws perfectly smooth, and a nail can be driven through it very cleanly and without disturbing the surrounding part—that is, it neither cracks, splits, nor tears, as wood sometimes does. It is claimed it can be worked without difficulty or injury. So far as grain is concerned, it has none; the layers cause a sort of grain on the edges, but of course it counts for nothing there. The proposition is that it can be readily polished, finished and decorated upon the surface in any conceivable or desirable manner, or sawed, planed, and worked the same as wood.

It is believed it has an endurance equal to or greater than most wood, and satisfactory tests are said to have demonstrated it to be fire and water proof to an extraordinary degree. It can hardly be soaked or burned. It is claimed a roof constructed of it could not burn through in less time than twelve hours, while the drier it is the greater its power of resistance to fire.

It has been used for floors and ceilings, and appears to have substantiated all that is claimed for it in that direction. It has also proved a success when made into friction wheels, and this is a good test of the wear and tear it can withstand. Paper friction-wheels are made which soon give way, and sole-leather wheels, though much better, cannot stand the grief long. A wheel 1¾" thick, costing 20 cents, has outlasted three sole-leather wheels, 5" thick, and costing $1 50 each. The slabs, when of the same thickness as ordinary lumber, are a large per cent. heavier, and for that reason can not be so well used in certain directions. This objection arises as to table-tops, buggy bottoms, and in various other uses. In many cases a less thickness and consequently less weight would answer all requirements. It is proposed to use it extensively for veneers.

There are so many articles made out of paper or materials manufactured from straw, that the question naturally arises



CATHEDRAL OF BURGOS. GALLERY OF THE HIGH DOORWAY OR THE CROWN.—DRAWING BY ANTONIO HERBERT.

as to the real difference between straw lumber and the more durable kinds of paper-board. Nowadays nearly everything is made out of paper. Everybody has heard of paper car-wheels—we ride over them every day. It might then be reasoned that a substance which could be made into a car-wheel would do for a floor to walk on. The point needs elucidation. Car-wheels and straw lumber are not made alike, else there could be no patent on the latter. We have given a general idea of the manufacture of the lumber. Car-wheel stuff is made in a much more simple way in all the establishments regarding which the *Lumberman* has any knowledge. In the first place six sheets of ordinary brown paper are pasted together and subjected to a hydraulic pressure of 400 tons weight. Then these sheets are taken to the thickness of half an inch, and subjected to the same pressure, and the layers thus formed continue to be so pressed till of the right thickness and firmness. This is the process in the abstract. There is no chemical preparation. When made into the right shape iron plates are placed on each side of the paper interior, and all are firmly fastened together by a system of rivets, then an iron band or tire is added, and this constitutes the car-wheel. One which had made revolutions sufficient to the traveling of 250,000 miles, when taken apart showed the paper portion to be twice as compact and serviceable as at first, and worth twice as much for a new wheel. The same theory, it is thought, will apply to straw lumber. It will be observed, however, that the whole of a car-wheel is by no means made from paper, as many no doubt have supposed was the case.

Reference has been made to different kinds of straw lumber, but it appears that the patent under consideration is the only one that has been taken out. The gentlemen interested took great care to look the matter up thoroughly and ascertain the full facts. A patent office expert was retained, who made an elaborate investigation, and submitted a report, covering the last hundred years, upon all inventions pertaining to the manufacture and use of any substance or material of which straw was the basis. Nothing touching the subject of lumber was found by the research, and the company is satisfied that theirs is the only patent for straw lumber.

A test regarding the strength of the lumber demonstrated that a slab ⅜ in. thick, supported at each end, would bear up, before giving way, the same weight which would break down a pine board 1 in. thick, supported in the same manner.

It is naturally important to know how readily the raw material for this lumber could be supplied. An acre of ground will average about three tons of straw, and 1,000 acres, or 3,000 tons of straw, would make about 1,606,000 superficial feet of inch-thick slabs. The manufacturers have no fear about securing all the straw necessary, but if enough could not be obtained within a reasonable radius of territory, so that freights must be added, the cost of manufacture would become considerable. Upon the question of cost present facilities will not permit of the product being manufactured quite as cheaply as pine of the same thickness, but it is regarded as worth more than that lumber, and equal to hard wood. The great value of the invention is understood to rest in the fact that it will furnish a substitute for lumber when that commodity shall become, as it will, decidedly less plenty than it is now. But the projectors do not believe that the exhaustion of timber will make itself particularly felt for a half century into the future.

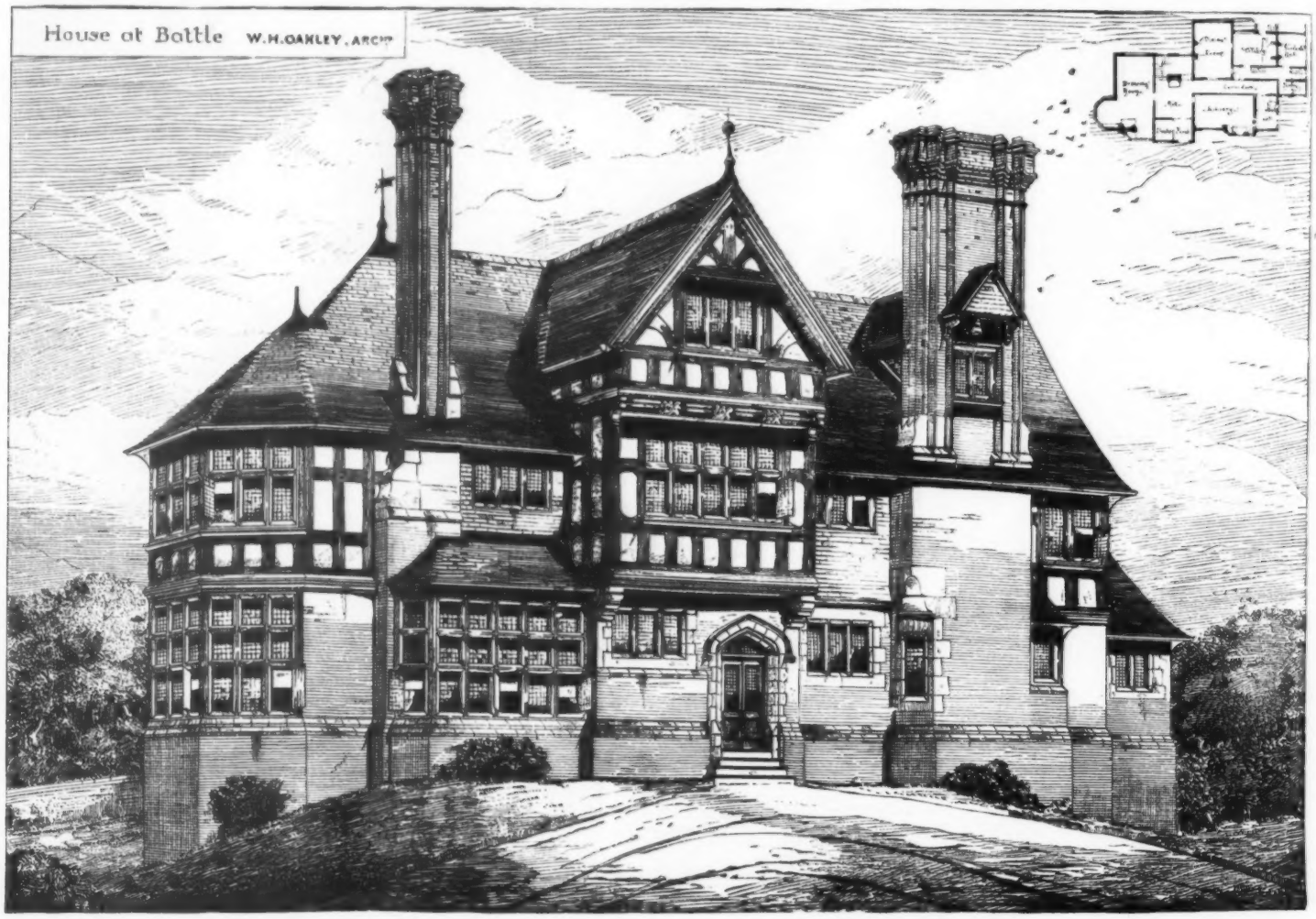
This lumber is now to be introduced in Chicago in the most practical manner. Mr. John V. Farwell, who is widely known as a heavy dry-goods operator, has decided to use it in a large new building now being erected, corner Market and Monroe Streets, six stories high, and covering an entire block. He, in company with Mr. William Edgar, who has charge of all the building permits issued under the city fire regulations, and Mr. J. M. Oadell, the architect of the new building, visited Lawrence recently and subjected the Hamilton lumber to all the necessary fire tests, to the satisfaction of all parties. An order was then given for 100,000 ft. of flooring, 480,000 ft. of ceiling, and a large amount for doors, counters, etc. Only 60,000 ft. were ready for shipment, which amount is about the capacity of the mill for a week. With this order and others now taken, the mill will be pushed for some little time. Several orders for friction-wheels have been refused.

The company is proceeding cautiously and will increase facilities as soon as the value of the lumber is established, and at the right time it is intended to add some $50,000 to $75,000 to the capital.

It is by no means absurd to presume, figuring upon the basis of present operations, that in the course of time straw lumber will become so perfected as to enter generally into building and manufacturing economies, though there would always be some question about trusting a straw block in place of an oak sill or stud. It is now proposed, however, to press the material into rails, balusters and newels.

HOUSE AT BATTLE.

This house stands on an eminence in a well wooded country. The materials are brick, stone, and timber. The work is being carried out from the designs and under the superintendence of Mr. W. H. Oakley, architect.—*Building News.*



SUGGESTIONS IN ARCHITECTURE.—A COUNTRY HOUSE.

RAISING GLADIOLI FROM SEED.

It is no more trouble to raise gladioli from seed than to raise the most common vegetable; with the simplest garden culture there is an almost absolute certainty of success. Prepare your bed in spring as for any hardy annual; the soil should be made fine and comparatively rich; sow the seed in drills, cover to the depth of one inch, hoe and weed sufficient to keep the soil light and clean, take up the bulbs after the first frost or before if ripe; store them during the winter in a dry cellar or room free from frost; plant them out again in the spring following, and in the ensuing summer very many of them will flower. With the convenience of a hot-bed, or frame, bulbs may be produced from seed in one season that will very nearly all flower the second. It will require a little more care and trouble to grow them in this way, but the increase in the size of the bulb will more than pay the extra cost. One of the chief advantages, however, in sowing in a frame is that in case of a heavy storm, the young plants may be protected by the sash that during all heavy rains should be kept closed, as the young plants rarely recover after the leaves have been bruised or broken down. I know of no pleasure in gardening equal to that of growing plants from seed. The certainty of getting some remarkably fine varieties is well balanced by some that are decidedly uninteresting; but upon the whole, when proper care is exercised in the selection of seed, a marked improvement, at least in the case of the gladioli, may be expected. The fact that the best rarely flower first will tend to create a warm and watchful interest. A pertinent and common question is, how to obtain the best seed. I answer simply by making a careful selection of the best varieties under cultivation. If an amateur, make a selection that suits your own taste, as you are not bound by society's rules as to what constitutes a perfect flower—keeping in view those of the best form, largest size, and of the most intense and positive colors; whenever they are marked or variegated, have the markings bold and distinct. Plant at least six inches apart each way. Without further care you will get some good seed, better quality, and far greater quantity will be obtained by cross fertilization, which should be done on a dry day, when there is but little air stirring. It is not absolutely necessary to cross-fertilize for good varieties; neither are you sure of success if you do, though it is probably the more certain way in the line of improvement. Yet very many of our most valued seedlings were accidentals, and each year produces varieties with colors and markings entirely new, but not at all times desirable—by leaving this part of the work to the bees. Gladioli dislike a stiff, clayey soil, but will thrive well in almost any other, its preference being for one of a moist, sandy character or light loam. If the soil be good they need but little manure, and that should be well rotted; successive plantings on the same ground should be avoided; change the locality of the bed, so as not to return to the same spot for at least three years. It is the better plan to make your ground very rich for some light crop this year, then plant gladiolus on it next; this plan cannot, however, be conveniently carried out in small gardens.

Increase of desirable sorts is effected by the small bulbs or bulblets that form at the base of the new bulb. Some varieties will average a hundred per year, others will produce scarcely any; this will account for the marked difference that exists as regards the prices of the named sorts, and also for the rapid increase of the more common varieties and the sudden disappearance of those that are greatly prized. Choice sorts are usually short lived unless they are increased by means of the bulblets. In many of our named sorts old bulbs will not produce good flowers, if, indeed, they produce any; consequently the bulblets of all favorite sorts should be saved and planted each spring; at least a sufficient number of them for the required stock. The question is frequently asked, "Do the varieties sport or return to the type, or do the white and yellow grounds become scarlet?" To all such queries I say emphatically no. "But then," continues the querist, "how is it that now all mine are red? the first year or two the collection was superb, the best kinds I could get; now they are not worth growing." I will tell you. The light colors have less vitality, as a rule, than the dark ones; consequently do not rapidly reproduce, and like delicate children, are but short lived. On the contrary, most of the older red varieties are nearer the type and possess healthy, strong constitutions, and increase with great rapidity. I have planted small bulbs of the variety brenchleyensis not larger than peas, and in the fall have taken from them more than two hundred well ripened bulblets. From a Shakespeare, a variety that never flowers well excepting from young bulbs, or many others of that class, I should consider myself fortunate if I could get a dozen. The explanation is, as I have said, the rare kinds die out; the more common ones multiply so rapidly, that quantity is kept intact at the expense of quality. It is impossible to keep up a good variety unless you grow them on from bulblets, or buy your stock from year to year from those who do. The bulblets may be sown in early spring in any convenient out-of-the-way place, and given the same treatment as recommended for the seed. If in good soil, they will, with proper attention, nearly all flower the second year. The first season

they require but little room; make your drills the width of a common garden hoe and about two inches deep, sow the bulblets so close that they will nearly touch each other, and they will do much better than if more scattered. Take them up in the autumn after the first frost, and carefully dry them and pack them away during the winter. The plantings should be made as early in spring as the ground can be got in order; no matter if there should be hard frosts after it will not penetrate the ground sufficient to injure them. For late flowering reserve some of the stronger bulbs until the 1st of July, which will keep back their flowering until about the 1st of October.

Manures.—There is another important point in the cultivation of the gladiolus that will apply equally well to the cultivation of all other plants, a point upon which success or failure usually turns, a point upon which more questions are asked than upon all others—it is, what is the best fertilizer? I have tried bones of all kinds; bones in their natural state, bones crushed, bones powdered, bones dissolved with sulphuric and muriatic acid, bone phosphates and superphosphates, and also guano. But for bulb culture all stimulating manures are dangerous and should not be used. It is true that some of these manures will give the flowers color and size wonderfully magnified, but not healthy bloom. My experience has been that bulbs produced with such help are diseased and short lived. The object of manure is to return to the soil those elements that go to produce plant life and which have to an extent been exhausted by the previous crop. For that purpose there is nothing that will take the place of well-rotted turf. For small gardens, where what is termed a rest is impracticable, it is invaluable and has no substitute. The next best for flowers is manure from the cow-house, which should be well rotted; they may be used together to good advantage. In this connection let me say that I mean these remarks to apply to small gardens only, as turf could not be got in sufficient quantities for general use; for that purpose stable manure occupies the first place among fertilizers, as it contains the largest number of ingredients required to sustain plant life and in the greatest variety of form. In ordinary gardening there is but little, if any, danger in using too much, that is, when it is evenly distributed.—*C. L. Allen, in New York Hort. Society's Proceedings.*

VALUE OF THE RYE PLANT.

SUCCESSFUL farming depends much on the selection of the plants to cultivate, as well as on enriching the soil and good cultivation. Plants, the chief merit of which may consist in filling vacancies between successive crops, may prove valuable aids. As an illustration we may cite the sowing of winter rye after the removal of crops in autumn, for early feed in spring, which will not interfere with subsequent and other growth on the same ground. So far as experiments in this way have been tried, we have found them quite successful. Last autumn rye was sown after the removal of a crop of potatoes. The land was in fair condition, having been moderately manured in previous years, and it was not incumbered with weeds. It was not plowed, but made mellow by passing the Acme harrow twice over its surface. The rye was sown by hand, at the rate of between three and four bushels per acre, and covered with the same harrow. The whole cost per acre, including the seed, sowing, and three harrowings, was slightly less than five dollars. The crop was a dense mass of green before winter, and it grew rapidly in spring, was in full head before the end of May, and was cut for green feed and for hay before the grain had fairly formed. Three separate portions were measured and weighed, in different parts of the field, which appeared to be a fair average. They all gave, with slight variations, twelve tons of green fodder per acre. A portion, after thorough drying for some weeks, was found to have lost about sixty per cent. of water, but it was quite dry enough for hay when it had lost half its weight. Six tons per acre was not a bad return, being less than one dollar a ton, not counting harvesting. Corn fodder was sown after it, in good time for autumn cutting. The interest on the land for the rye could not be reckoned as very large. Another portion of the rye stubble was left to sprout up again, which it did freely from the old roots, giving a smaller crop in time for a later sowing of corn fodder.

More commonly we have sown the rye in autumn, after the cutting and removal of the corn crop or of the corn fodder. It has always made a sufficient growth the next year, either for spring feed, or for plowing under as a green manuring crop, to precede any late-planted spring crop, as corn fodder, millet, or turnips. The same inexpensive mode of putting in the seed was adopted as already described. There is no difficulty in completely turning under a crop three feet high, with a heavy chain attached to the plow in the usual manner. Experiments have not been made to test the comparative value of a ton of green rye or a ton of green clover thus buried as manure. Analysis shows them to be of nearly equal value in composition, but the rye has not the deep loosening roots of the clover, and it is doubtless much inferior. But the ease and certainty with which a crop of rye may be raised, as compared with a crop of clover, and the shorter time for it to make full growth, give it certainly some important advantages.

Another use to which rye may be applied, is in sowing among corn for fall feed. After the corn has attained full growth, or some time in August, sow two or three bushels broadcast among the corn. Then having muzzled the horse, to prevent eating the tops of the corn, give it a thorough cultivation. The seed will soon germinate, and by the time the corn is cut and drawn off (according to the easy method figured and described on page 199 of vol. ix. of *Rural Affairs*), a rich and heavy growth of green pasturage will occupy the ground, and will last through that period of commonly dry pasture. It may be eaten down by horses and cattle, but will sprout up again and afford a good spring feed, or a copious green crop for plowing under.

If corn had been raised in an orchard (one of the best crops for cultivating among young or older trees), a soft bed of herbage can be provided in the way just described for all dropping fruit or windfalls, which will prevent to a great extent the bruising of this fruit, and render it valuable for keeping for home use.

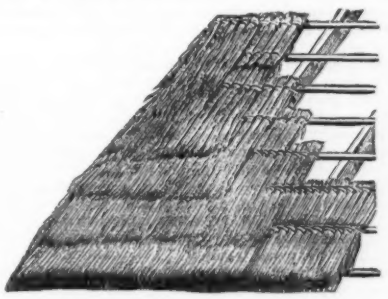
It is not a good crop for summer feed from spring sowing, as it will not make much growth some seasons, and is rather easily affected with dry weather; but sown late in summer it will continue fresh and green through the autumn. It appears that a certain degree of actual freezing is required to cause it to form heads. Last winter we had a portion of a field sowed and harrowed during a thaw about the middle of February. It did not come up till early in spring, and was about two weeks later than the other rye; but the freezing of the sprouted grains in March was sufficient; and it formed heads four feet high, and gave a heavy crop of fodder.

Rye possesses much value as a crop with which clover and grass may be successfully seeded, on account of the small amount of shade which its leaves afford as it is approaching maturity, and for this reason grass rarely fails when sown with a crop of rye intended for ripening its grain.

Its advantages then, to sum them up, are: 1, its value to plow under as a green crop, raised at a little cost; 2, the fine spring feed which may be obtained from a fall sowing; 3, an excellent autumn feeding sown with maturing corn; 4, the certainty and cheapness of any of these crops; 5, its occupying the vacant time between the autumn harvesting of other crops and the sowing or planting of its successors late in spring or in early summer; and the success which usually attends the growth of grass sown with it when raised for the straw, grain, or seed. These many uses recommend it as a valuable crop for the attention and use of farmers, without resorting to the manufacture of the grain for deleterious purposes.—*Country Gentleman.*

HOW TO MAKE STRAW ROOFS.

FOR twenty years I have been making roofs of temporary shelters with rye-straw. The straw should be cut when fully ripe, kept straight, and thrashed clean by hand with a flail. All the grain must be removed from the straw, or rats and turkeys will make sad havoc with the roof. I do not make the building more than 20 feet wide. Any kind of soft wood poles will do for rafters, as small crooks will not show in the roof. Make the pitch very steep, at least half-pitch, or the ridge-pole 10 feet higher than the plates of a 20 foot building. The rafters may be cut to project 1 foot, or if poles are used for rafters, small poles, say 2 inches in diameter, may be cut 2½ feet long, flattened at the upper end, and nailed to the rafter resting on the plate, thus making the desired projection. Nail a good solid small pole, say 1½ inches in diameter, on the end of the rafters, all around the building, splicing when necessary, then use inch poles for sheathing, nailing them on about 9 inches apart. The roof should be hipped at the ends, as it saves gables and looks better. Commence the roof with a loose bunch of straw; compact it in the hands. Let the butts project about 3 inches over the outside, and tie it to the outside pole and to the one next above. This front row must be doubly secured, to prevent the wind from lifting it. Lay on another row of bunches, letting the butts come down even with the first, but securing with but one tie to the third row of poles. Put on the third row of bunches, letting the butts come about 9 inches up on the two front rows, and proceed shingle fashion until the roof is completed. Finish the roof by binding a good



ROOF SHOWING THATCHING.

supply of straw across the comb, running one or more wires along on each side, and sewing through with wire. For this one will need an assistant on the underside to return the wires through the straw. The corners, also, would be better secured with a little wire. Trim off the eaves with a knife. I have always used willow ties to fasten on the straw, but one can use twine or the kind of wire used by the binders. An expert hand may make a good roof and tie it with straw. I have a shed made in this way 30 by 20 feet, used for storing machinery, the whole cost of which was fifty cents for nails, and four days' work for two persons; the posts, poles, straw, and ties were home products. A roof thus made and not disturbed by stock, rats, or poultry, will last twelve or fifteen years. But if used for stock, it must be put up high enough, so no animal can reach the eaves on a cold winter night. If for storage, and away from stock, the sides may be closed up the same as the roof, only not so thick. —*Kentuck, in Amer. Agriculturist.*

SOILS AND ROOT FORMATION.

SOME diversity of opinion appears to exist as to the relative influence of rich and poor soil on the formation of fibrous roots. I do not think that any hard and fast line can be laid down in this matter, as it will be found that the conditions under which fibrous roots are most freely produced are of a somewhat varied nature. Whether roots multiply most in poor or rich soils I cannot say, but I do know that whereas in some poor soils fiber is freely made, in others the very reverse is the case. If we pot a strawberry, or indeed any free rooting subject in silver sand, or in pure sand of any kind, we shall find that in a very short space of time the roots push down to the bottom of the pot, and, should the same happen to stand on any free kind of fibrous compost, the roots will quickly find their way into it. Pot the same plant in some fibrous material, however poor, and this tendency to downward progress will not be so marked; on the contrary, the compost, even to the surface, will be filled with fibrous roots; the inference to be drawn from which is that the mechanical composition of the compost has much to do with root production. At the same time mix intimately with this poor sandy material some manurial ingredient, and the same result will be obtained; the roots, finding what they need at home, will be in no hurry to seek fresh feeding ground. This being the case, it is obvious that whatever is added to the soil with a view of enriching it should be in the form of small particles evenly distributed throughout the whole body of earth. In the case of composts made up for potting this is very important, and the observance or neglect of it will exercise considerable influence upon the progress and well being of the plants themselves; for it may be laid down as a rule that unless the whole body of soil becomes well filled with feeders, a vigorous, healthy existence is, to say the least, improbable. That something more than richness in the soil is needed for the free multiplication of fibrous roots is evidenced by the fact that fat loams, when of a stiff, tenacious nature, require the addition to them of some light porous material. Mix with them some leaf mould, cocoa fiber, poor fibrous peat, or any porous material, however poor, and there will be a perceptible increase in the amount of fibrous roots made in them. Every one knows how freely roots are made in moss, in old tow, or sawdust, and we use leaf-mould for seed sowing and for seedlings in their earlier stages of growth, simply because we know that, being very porous, that is to say, the particles composing it not coming close together, tender rootlets can ramble freely among it. It is probable that poverty more than any other thing influences root production, but if thereto we add richness, we get the soil best calculated to induce the formation of a larger amount of healthy fibers.

It may be in the remembrance of your readers that Mr. Peter Henderson, of New York, found sifted moss of great value in the raising of seeds, and as the results obtained by him bear directly upon the question of root production, it may be as well to recapitulate the circumstances attending them. The seed-bed was formed as follows: On a thin layer of loam was placed about one inch of sifted sphagnum moss, and on the top of this came another thin layer of loam, in which the seed was sown, covering it with sifted moss. It was found that the roots of the young plants quickly pierced the loam, not making much fibers in it; but when they came to the moss, they stayed there, quickly forming a mass of fibrous roots, thus rendering the transplanting a more sure and easy process than if soil alone had been employed. Not only was this the case, but the seed germinated in a much more satisfactory manner when covered with moss, a very much larger percentage of young plants coming up than where the covering consisted of fine soil. From this it would appear that sphagnum moss exercises a more stimulating effect upon root action than good, rich, fibrous loam; indeed, we know such to be the case, for do we not envelop the stems of tree ferns, dracænas, aralias, and such like plants, in order to draw roots quickly from them? and we also use it for many tender or succulent-rooted subjects. It is probable that we should find moss valuable for many purposes for which it is not commonly used, and that in the case of delicate-rooted ferns, palms, etc., it would, if mixed with the soil, be the means of increasing root production. Much has been written of late about a kind of fertilizing moss, but this appears to be a failure; at the same time I see no reason why a prepared moss should not take the place of soil in the case of many plants which are naturally not strong rooted. Mr. Henderson top-dressed some root-bound plants with moss with a sprinkling of bone-dust in it, and the effect was almost as marked as if they had been shifted, a result probably as much due to the stimulating effect of the moss as to the nourishment contained in it. It is a not uncommon practice to soak turfs in liquid manure for layering strawberry runners in, and why should we not treat moss in the same way? The substitution of a light material would be advantageous in more ways than one, as, owing to diminished weight, the cost of transport would be less an important item to market growers, who necessarily have a considerable journey to make in bringing their plants to market, as well as to purchasers who have railway carriage to pay. Probably one reason why roots multiply more in moss, leaf-mould, old tan, etc., than in close-grained soils, is that they cannot push uninterruptedly through them, but are constantly encountering obstacles which cause a halt in their progress, and we know that no sooner does the main feeder experience a check than lateral roots are at once pushed from it. It is a knowledge of this fact which induces many to mix brick rubble and other organic material with the soil of their borders, as the roots, instead of traveling swiftly through the border, are now and then arrested in their course, and are, in a measure, obliged to ramify.—*J. Cornhill, in The Garden.*

FORMATION OF THE DIAMOND.

By A. B. GRIFFITHS, F.C.S., etc.

IN this short note the author is desirous of pointing out that we can theoretically account for the formation of crystallized carbon in nature; although scientific men generally hold the opinion that the "origin of the diamond is entirely unknown." We know that the diamond has been found in a fine-grained sandstone in Brazil, and is principally found in an alluvial matrix of sandstone and quartz pebbles. Knowing these facts and that there are only three methods by which crystals are formed—namely, by fusion, by solution, and by sublimation; and as the diamond has been found in sedimentary rocks and in an alluvial matrix of sandstone and pebbles, and knowing that sandstone and pebbles are produced by the action of water, hence their name of aqueous rocks; and as aqueous or sedimentary strata are often fossiliferous, we may draw an inference that the carbonaceous matter of the fossils (plant and animal remains) has been dissolved by highly heated water aided by great pressure existing in the crust of the earth.

It is a well known fact that highly heated water, aided by pressure, can dissolve silica, as in the Geysers of Iceland, etc., where it is deposited round the mouth of the vent forming "the sinter," and also we have the experimental researches of De Senarmont (*Ann. de Chimie*, III., xxxii., 129), and others on the artificial production of crystallized minerals, as quartz, mispickel, corundum, heavy spar, etc., by the prolonged action of water at high temperatures and pressures; and I think we can see no reason why highly heated water or water-gas should not have the power of dissolving the carbonaceous matter of fossiliferous plants and animals, and then, on cooling, depositing the carbon in the crystallized condition forming the gem known as the diamond. As to whether the diamond was formed by sublimation, we can draw no inferences from facts or from nature; so must put this method of forming crystals on one side, as not being able to solve the problem; and further, the diamond cannot be formed by fusion, because we know that crystallized carbon, in the form of graphite, is formed by fusion (as "kish" in the manufacture of pig-iron).

Therefore, it appears from these views on the subject that the diamond has been formed in nature by the solvent action of highly heated water or water-gas, aided by enormous pressure on the carbonaceous matter of fossils contained in sedimentary rocks followed by slow cooling.—*Chem. News.*

ELASTICITY OF RAREFIED GASES.—At the lowest pressures which have been experimentally reached (two tenths of a millimeter) there does not appear to be produced any abrupt change in the law of the compressibility of gases; they still follow the law of Mariotte. It may certainly occur that a sufficent rarefaction, acting like a great elevation of temperature, may cause gases to follow the law, $p(v-a)=c$, as in the case of hydrogen; but it is far from this to the limit of which M. Mendeleef and M. Siljerström, a state in which gases become infinitely little compressible.—*E. H. Amagat, in Comptes Rendus.*

ALUMINA.

THIS term has been adopted in modern nomenclature to signify the earthy basis of alum or pure clay. This earth is one of the most extensively diffused in nature; its properties (at least the most important of them) have been familiar to mankind from the earliest antiquity, and on every account it deserves particular attention.

Alumina is nowhere found native in a state of purity, and it is a little remarkable that in all the natural clays, in which some of its characteristic properties are the most conspicuous, it never forms even half the composition, and generally no more than a third or fourth; and, on the other hand, it is found nearly uncombined in the hardest gems and the corundum, minerals in which its existence was for ages unobserved, till the experiments of the illustrious Bergman, and where it exhibits properties widely different from those of clay. The term alumina, therefore, is well chosen, both as it suggests the most important saline combination of this earth, and as it prevents those erroneous ideas of its properties which might attach to the ancient name of clay.

Alumina, when pure, is white, and without taste or smell. The natural clays, indeed, and the other earths that contain much alumina, have a peculiar earthy smell when breathed upon, which is a test of some use in mineralogy, but this appears to be owing to the combination of clay with the oxide of iron, and certainly does not belong to pure alumina. This earth is incapable of artificial crystallization, nor is it, like silex, found native in a state of absolute purity and crystallized. However, in one or two varieties of the corundum gems, alumina forms by far the greater part of their composition, and thus circumstanced, this earth is regularly crystallized and intensely hard. A peculiar difficulty lies in the way of ascertaining the true specific gravity of this earth; in the gems it is considerable, being from about 3·99 to 4·28.

Alumina, either as it exists in the natural clays or when prepared by art, till it has been exposed to a red heat, unites readily with water into a very tenacious, unctuous-feeling mass, which differs from all other wetted earths in being so plastic that it may be turned on a wheel, or moulded into any form. On adding more water it becomes gradually and equally diffused, making the liquor uniformly milky, and remaining very long suspended before it subsides. It is not, however, in any degree soluble in this fluid. Plastic clay retains water in greater quantity, and for a longer time than any other earth; on drying, if heated very gradually, it shrinks in every direction, and at last cracks into a number of pieces, and returns to its original state. When thus dried at a moderate heat, it is soft, greasy, brittle, and crumbly; when rubbed, it takes a good polish, and remains equally plastic as before, on the addition of fresh water. But if it is dried at a full red heat, it becomes extremely hard, so as to strike fire with steel, is harsh to the touch, and now no longer mixable with water into a plastic mass, nor does it absorb any sensible quantity of this fluid. Its original properties, however, are regained on solution in an acid, and precipitation by an alkali, or *vice versa*.

Alumina in many instances gives its characteristic properties with respect to union with water, to a very large proportion of any other earth with which it is mixed. In the natural clays, as we have mentioned, it never forms quite half the mixture. The very pure aluminous earth of Schmnitz, according to Klaproth, contains only 45 per cent. of alumina, and in the best porcelain clays the alumina is seldom more than 25 to 35.

The action of heat on moistened alumina is very striking. The first effect is to expel most of the large quantity of water which it has absorbed in becoming plastic. The greater portion of this fluid is expelled at a very low red heat, or at the point at which the earth assumes that entire alteration in its texture as to lose the power of again uniting with the water which it has lost. In consequence of this it shrinks in every direction. But the loss of weight and diminution of bulk do not stop here, for they both continue (the former in a diminishing ratio, the latter tolerably uniformly) up to as intense a heat as has ever been produced in furnaces. Hence it is that clay by its contraction affords a certain indication of increase of heat as all other bodies do by their expansion; not that this earth, however, is incapable of expansion by heat, for, like every other substance in nature, alumina dilates when heated and contracts when cold; but this is only observable when the heat applied is not more than the highest to which it has been exposed since its plastic state; above this point the contraction peculiar to this earth (produced either by actual loss of water or a different arrangement of its component particles) begins again to operate, and the extreme limit of its shrinking has never yet been precisely determined. A scientific manufacturer, Mr. Wedgwood, very ingeniously applied this property of clay to the construction of a thermometer for measuring the more intense degrees of heat, where the common instruments were inapplicable, but, though a valuable instrument, it is not susceptible of that degree of accuracy which has often been attributed to it.

M. Saussure observes that when alumina is precipitated from alum by ammonia or by carbonated ammonia, it is capable of existing in two forms, according to the manner in which the solution of alum was made; if no more water was used than necessary to dissolve this salt, the precipitated earth when dried at about 80° is a white, friable, light, very spongy earth, sticking to the tongue, which the author calls spongy alumina. But, on the other hand, if the alum is dissolved in a very large quantity of water, the precipitate dried at the same moderate warmth will be transparent, yellow, brittle, cracking in the heat of the hand, like rolls of sulphur, with a smooth concboidal fracture, not appearing like an earth, nor adhering to the tongue, and not again mixable with water. This the author terms gelatinous alumina. At the above temperature of about 80°, both species contain an equal quantity of water, though the spongy occupies ten or twelve times the bulk of the gelatinous. But at a higher heat they differ much in the power of retaining water. The spongy alumina loses at a full red heat, rather less than is sufficient to melt silver, all the water which it had absorbed amounting to 58 per cent.; so that 100 parts dried at 80° are hereby reduced to 42, and lose no further weight by the highest intensity of heat that can be given. But the gelatinous alumina dried at 80° is said by M. Saussure to lose only 43 per cent. of its weight at a silver-melting heat, 48¼ at a heat of 130 of Wedgwood (or sufficient to melt cast iron), and appears never at any higher heat to alter further in its weight.

M. Saussure further remarks that contraction of clay (in the higher heats at least) cannot be exclusively owing to the loss of water, or to any loss sensible to the balance, since the diminution in weight from the thirteenth degree of Wedgwood to the highest intensity of heat is very trifling, whereas the contraction in the bulk of the clay, within these terms, is more than a fourth of its bulk.

Pure alumina is infusible in any heat that furnaces can procure, if not in contact with an alkali, or with any other earth which may operate as a flux. However, when exposed to oxygen gas from the blow-pipe, supported on a piece of charcoal, both Ehrman and Lavoisier found it converted into a milk-white globule, imperfectly fused, and intensely hard, so as to scratch glass nearly as the diamond. Some doubt, however, arises whether the alumina might not still contain a minute portion of potash, as it was prepared by precipitation from alum, the difficulty of procuring perfectly pure alumina in this method being very great. Besides, as all charcoal contains some alkali, this might have assisted in the fusion, so that it is still doubtful whether pure alumina is capable of melting without addition, by any known heat. The other earths promote the fusibility of alumina when mixed with it. Gerhard found this earth fusible in a chalk crucible, but not in one of clay; Klaproth found lime to melt in a clay crucible, and not in one of chalk; but it is certain that alumina is one of the most refractory of all bodies in nature, and hence its use in its natural clayey mixtures in forming crucibles, furnaces, and vessels for resisting fire, and containing other bodies to be exposed to heat.

Fused with alkalies, alumina does not run into a clear glass like the other earths, but forms an opaque, puffy, white semi-vitrescent, pasty enamel. So Klaproth found the corundum, in which the alumina is about 84 per cent., fuse with its own weight of carbonated soda in an intense heat, into an opalescent, greenish-white, hard glass.

Alumina is soluble in most of the acids, with more or less facility, and without effervescence, unless newly precipitated from a solution, and still retaining a portion of carbonated alkali, which it does with considerable force.

For a complete solution, the assistance of heat is generally required, unless it be effected by double decomposition, as where acetated alumina is formed by adding acetated lead to alum. This earth is much more soluble when in its plastic state than after it has been heated, and, most of all, immediately after precipitation from its solution either in an alkali or an acid.

Alumina dissolves with ease in the pure fixed alkalies, and even in ammonia if newly precipitated. If alumina in this fine state of division be put into three or four times its weight of a solution of potash, and heat applied, it dissolves like wax in oil, and by slow evaporation dries into rhomboidal pieces. Even the hardest aluminous stones, such as the corundum, yield to fusion with alkali with particular management. This solution lets fall the alumina when saturated with any acid, an excess of which redissolves the precipitate. Muriated ammonia also separates the earth from the alkaline solution by a complicated affinity, the potash uniting with the muriatic acid, and the ammonia thus expelled determining the precipitation of the alumina, which when properly edulcorated and dried is now perfectly pure.

In many respects alumina resembles silex so strongly as to have been frequently mistaken for it; in hardness the aluminous gems surpass even that of rock crystal; both earths are soluble in fixed alkali, precipitable thence by an acid, resoluble in a slight excess of acid; and when in strong aggregation, the aluminous earth resists the solvent power of acids as completely as the silicious. The most conspicuous difference between them, as they occur in analysis, is the following: Silex when redissolved by excess of acid, after being first precipitated by it from its alkaline solution, is entirely again separated by the application of heat, and by evaporation nearly to dryness, and then the earth remains insoluble on any future application of acid. Alumina, on the other hand, though the solution has been evaporated to dryness (if not otherwise decomposed by heat), remains again soluble on affusing fresh acid, and thus may be completely separated from the silex.

From its strong affinity for magnesia, lime, barytes, strontian and other substances, as well as silex, it may be imagined how difficult it is to procure this earth absolutely in a state of purity.

Pure alumina may be prepared either by precipitation from alum, or from the finer clays or aluminous earths. Each method has some particular advantages, but in each some precautions must be taken to insure its efficiency.

In alum, the only earth is that which is intended to be obtained, which is a considerable advantage, but the affinity of the earth both for sulphuric acid and for potash, is at least as great as that which it shows for other earths, and accurate experiments have shown that a single precipitation from alum can scarcely ever be depended on to obtain the earth absolutely pure. Bertholet found that alumina precipitated from alum, even by pure ammonia, and well edulcorated, still contained a small portion of sulphuric acid, as was proved by affording a sulphuret when strongly heated with combustible matter. He, therefore, recommends that the first precipitate from alum, by ammonia, be redissolved in nitric acid, purified from sulphuric acid by nitrated barytes, and again precipitated by the same alkali, and, after due edulcoration, dried in a heat sufficient to expel the ammonia, whereby the earth is now obtained pure.

Alumina has a strong affinity for the vegetable and animal oils. Alum in solution, mixed with soap water, curdles it completely, and the coagulum is an intimate union of this earth with the oil of the soap, forming a soft, flexible mass, which, when dry, remains supple, is insoluble in alcohol, and, after fusion, becomes transparent.

The affinities of alumina for the acids are in the following order: Sulphuric, nitric, muriatic, oxalic, arsenic, fluoric, sebacic, tartareous, succinic, mucous, citric, phosphoric, formic, lactic, benzoic, acetous, boracic, sulphurous, nitrous, carbonic, prussic.—*Pottery and Glassware Reporter.*

UTILIZATION OF BLOOD.

By P. MARGUERITE DELACHARLONNY.

THE author gives the proportion of nitrogen in dried blood as 12·15 to 18·73 per cent., and the phosphoric acid at 1·63 to 2 per cent. The value of the blood of the 43,000,000 animals yearly slaughtered in France he estimates at 21,000,000 francs. The author describes various methods proposed for testing blood so as to prevent nuisance. A mixture recommended for this purpose by the Conseil d'Hygiène de la Seine is as follows:

Sodium sulphate	0·60	kilo.
Crude phenol	0·15	"
Common vinegar	0·15	"
Sulphuric acid	0·025	"
Water	2·500	"
	3·425	"

This quantity is to serve for 100 liters of blood.

QUASSIIN.*

By A. CHRISTENSEN.

THE literature upon the chemical constituents of quassia wood is very inconsiderable. In 1806 Thomson† mentioned that by digesting quassia wood with water and evaporating he obtained a very bitter substance, which when warm was soft, and became brittle upon cooling, and which, in his opinion, consisted principally of the pure bitter constituent; it gave a slight precipitate with tincture of galls. In 1811 it was stated by Pfaff‡ that the bitterness was completely extracted by cold water. In 1826 Buchner introduced 1 grain of the alcoholic extract into a wound in a rabbit, which was followed by the death of the animal. Another investigation of the extract by Keller§ contains nothing of importance.

Quassiin was first prepared by Winckler‖ in 1835 as follows: Three ounces of quassia wood were extracted with 2 pounds of 80 per cent. alcohol. After evaporation in a water-bath the residue was dissolved in water, and the solution filtered and evaporated to the consistence of an extract. The extract was exhausted with absolute alcohol, evaporated almost to dryness, and then again exhausted with boiling water. The light yellow solution, decolorized by animal charcoal, left after slowly evaporating crystals of quassiin. Winckler described this substance as crystalline, difficultly soluble in water and freely in alcohol, faintly alkaline, giving a precipitate with tannic acid, and as being obtained crystalline most easily from water.

Subsequently Wiggers¶ prepared quassiin by repeatedly boiling 8 pounds of quassia wood with water, evaporating the filtered decoction to 6 pounds, cooling, adding lime, and allowing the mixture to stand a day with frequent shaking, filtering, evaporating nearly to dryness, and then boiling with 90 per cent. alcohol. From the solution, which, according to Wiggers, contained, besides quassiin and coloring matter, some sodium chloride and potassium nitrate, the alcohol was distilled off and it was then evaporated to dryness. The residue was dissolved in the least possible quantity of alcohol and mixed with a considerable quantity of ether, which separated much coloring matter. The filtrate was now again evaporated, and dissolved in absolute alcohol and ether, and this repeated until the residue was colorless and free from saline matter. Lastly the ethereal solution was poured into a small quantity of water and left to evaporate spontaneously.

Wiggers found for quassiin the formula $C_{30}H_{32}O_8$. According to him it loses 1·3 per cent. of water at 100° C., and 0·37 per cent. more upon fusing. The melting point, he says, lies a little above that of the resin. He found it dissolve in 220 parts of water at 12° C., and it did not neutralize acids. It crystallized by spontaneous evaporation from a solution in alcohol and ether which was mixed with water, and also when a warm saturated alcoholic solution was mixed with boiling water and allowed to cool. The quassiin of Wiggers was precipitated by tannic acid, but not by metallic salts.

In commencing the present investigation, Herr Christensen first directed his attention to find a new method of preparation, since the methods of Winckler and Wiggers yielded it in a very impure condition, and the operations for its purification would involve considerable loss. The author tried two methods that are available in the extraction of several bitter substances: (1) treatment of a solution of the watery extract with bone black and exhaustion of this with alcohol; and (2) precipitation of the watery extract with tannic acid, decomposition of the washed precipitate, extraction with alcohol, etc. In both cases, by evaporating slowly, he obtained tabular crystals, having an intensely bitter taste, leaving on combustion no ash, difficultly soluble in water and fairly soluble in alcohol. The solutions gave with tannic acid a dense white precipitate.

Notwithstanding that the quassiin is tolerably completely removed by bone black, as is shown by the fact that the filtrate tastes only slightly bitter, the tannic acid method has the advantage that it yields the purer product. The following method was adopted by the author for the preparation of quassiin:

Five kilos of quassia were boiled several hours with two successive quantities of water. The united filtrates were evaporated, at first over an open fire, subsequently on a water-bath, to 1½ liters. After cooling this was filtered and the filtrate precipitated with tannic acid, taking care to keep the reaction neutral or faintly acid by the addition of carbonate of soda, since the compound of quassiin with tannic acid, like many similar compounds of bitter substances with that acid, is very soluble in it. The precipitate, after the addition of well-washed pipe-clay, is easily collected and removed by filtration. The precipitate after being repeatedly washed was mixed while moist with a considerable quantity of freshly precipitated lead carbonate, and evaporated to dryness in small portions, with frequent stirring, upon a water-bath. The mixture was extracted four times with alcohol, the alcohol distilled off, and the residual liquid evaporated until the separation of crystals of quassiin, which were washed and dried between filter-paper. The filtrate yielded more crystals upon further evaporation, and some more quassiin was separated by shaking it with chloroform. Lastly, the quassiin was recrystallized from ether-alcohol and water.

In the place of lead carbonate, calcium hydrate also was used for the decomposition of the tannic acid compound, and an alcoholic solution obtained that was not so much colored, but the yield was smaller.

Upon evaporating the watery extract of quassia wood, a considerable precipitate separated as a smeary mass. This was treated with freshly precipitated lead carbonate, evaporated almost to dryness, and extracted with 84 per cent. alcohol. After the alcohol had been distilled off, and the liquid sufficiently evaporated, some quassiin separated, but in an impure condition.

Quassiin is very freely soluble in chloroform, and by shaking an aqueous solution of it with chloroform it can be nearly entirely removed. The author therefore tried to obtain the quassiin from the aqueous extract of quassia wood by simply shaking this with chloroform; but the practical difficulty was met with that the chloroform does not completely separate it, and a pasty, slimy mass was formed, the consistence of which was not altered even upon warming. After the chloroform had been distilled off a very impure residue was left, from which the quassiin was only

* Abstract of a communication from the Strassburg Pharmaceutical Institute (*Archiv*, xx., 481).

† *System der Chemie*, iv., 47.

‡ *System der Materia Medica.*

§ Buchner's "Repertorium," ii.

‖ Buchner's "Repertorium," liv. (1837), 85, and lxv. (1839), 74.

¶ *Annalen der Pharmacie*, xxi. (1837), 40.

obtained by repeated recrystallizations from ether-alcohol mixed with a little water. Neither can direct exhaustion of the quassia wood by chloroform be adopted in the preparation of the quassiin, since much resin is taken up with it, and this can only be separated by the ether-alcohol method, which involves considerable loss. The last two experiments show, however, that quassiin exists as such in the wood, and is not a product formed during the treatment.

The quassiin, obtained as above described with tannic acid, was purified by recrystallization from the smallest possible quantity of warm alcohol, in which it is so much more soluble than in cold that the solution solidifies into a paste upon cooling. After the crystals had been washed with dilute alcohol and dried between filter-paper and then over sulphuric acid they were white and gave a colorless solution. They were recrystallized once more by the addition of boiling water to a hot concentrated alcoholic solution; the crystals that separated on cooling showed the same melting point as those of the first crystallization, and were used in the further experiments.

With respect to the proportion in which quassiin occurs in the wood, the author obtained from 18 kilos of Jamaica wood (*Picræna excelsa*) 12 grammes of impure substance, equal to 0·6 per 1,000. But in treating a subsequent consignment, both of Jamaica and Surinam wood, he found to his surprise that in repeated experiments upon considerable quantities of both kinds he could obtain scarcely any quassiin. A sample of *Quassia amara* wood, that yielded 2·8 per cent. of extract, and one of *Picræna excelsa* wood, that yielded 2·6 per cent., yielded no quassiin. The sample of *Picræna excelsa* wood that gave 0·6 per 1,000 of quassiin yielded 3·2 per cent. of extract. The author is unable to explain the cause of this difference; but if the value of quassia wood is dependent upon the proportion of quassiin it contains, the results do not afford much justification for the exclusion of the Jamaica wood from some pharmacopœias.

Pure quassiin forms very thin rectangular double refracting crystalline scales. It has an intensely bitter taste, is without smell, permanent in air, and gives neutral solutions with alcohol, water, etc. It melts at 205° with slight puffing—possibly due to the giving off of water—to a yellow resin-like mass, which upon solution and recrystallization is recognized as unaltered quassiin.

Water, left in contact with finely powdered quassiin several days, with frequent shaking, at 15° C., dissolved 1 part in 1,230. A warm saturated solution left forty-eight hours at 15° C., with frequent shaking, contained 1 part in 735. Boiling water dissolves quassiin with difficulty, but much more freely than cold. In alkalies it dissolves with a yellow color very readily upon boiling, and separates unaltered on the addition of acids, becoming again colorless. It is dissolved by alkalies in the cold somewhat more easily than by water, turbidity resulting upon neutralizing the liquid with acids. Boiling alcohol dissolves it very freely, but cold alcohol much less so, 1 part of quassiin requiring 30 parts of 84 per cent. alcohol at 15° C. In ether and petroleum spirit it dissolves with difficulty, but very freely in chloroform, of which 2·1 parts dissolve 1 part of quassiin. A solution in chloroform is dextrogyre, the specific rotation being $\alpha_D + 37·8$.

Quassiin contains no nitrogen. After being dried to a constant weight over sulphuric acid, it did not alter in weight when exposed for an hour to a current of dry air at 100° C., and gave upon analysis results corresponding with the formula $C_{21}H_{42}O_9$.

	Calculated.	Found.
C	66·66	66·90
H	7·52	7·44
O	25·82	25·65

An aqueous solution of quassia is not rendered turbid by metallic salts. A saturated alcoholic solution gives no precipitate with a similar solution of neutral lead acetate, and upon evaporation the quassiin separates unaltered. Other saturated alcoholic solutions of metallic salts behaved similarly. Tannic acid produces in aqueous and alcoholic solutions of quassiin a white precipitate which is soluble in acids and in caustic and carbonated alkalies.

Dilute hydrochloric and sulphuric acids dissolve quassiin in the cold somewhat more freely than water, but 3 to 10 per cent. solutions, even after being heated in sealed tubes to 125° for an hour, did not reduce alkaline cupric tartrate, showing that quassiin is not a glucoside.

By treatment of quassiin with a 3 per cent. solution of sulphuric acid a new compound was obtained, crystallizing in fine needles, and having only a slightly bitter taste. It melted at 237° C., did not lose all its water of crystallization (four molecules) till 110° C., and when anhydrous gave upon analysis results corresponding with the formula $C_{21}H_{38}O_8$. It was very sparingly soluble in water, required 180 parts of alcohol at 15°, dissolved very freely in caustic potash and caustic soda, and gave no precipitate with tannic acid. There was also a formation of resinous matter that could not be crystallized and possessed an intensely bitter taste.

A strong solution of quassiin in chloroform decolorizes bromine, with formation of hydrobromic acid. The author obtained a bromine compound as a white amorphous mass, with a taste even more bitter than that of quassiin; this compound dissolved in alkalies with an intense yellow color, distinctly produced by the smallest traces, and at the same time lost its bitter taste almost completely.

An experiment made to test statements as to the occurrence of an essential oil in quassia wood gave negative results, a small quantity of solid white substance that collected on the surface of the aqueous distillate proving to consist of free fatty acid.

MODERN THEORIES OF COLOR.

A GOOD *résumé* of the opinions at present held in regard to color is given by M. J. Soury, in the *Revue des Cours Scientifiques*. The theory, which may now be called old, though it replaced that of Newton, is the Young-Helmholtz theory. According to this, the retina of man possesses three distinct kinds of nerve fibrils, each of which is capable of distinguishing one of three colors supposed to be fundamental or elementary. One of these sets of fibers is sensible to red alone, another to green, and the third to violet or perhaps to blue. Our entire chromatic scale is made up of combinations of these three primary colors. Every sensation is due to the excitation of the fibers of the retina by these tints, each set of fibers being strongly stimulated by its own special excitant, and feebly stimulated by the others. In the case of red, for example, the terminal apparatus of the fibers adapted for conducting red are powerfully stimulated by the large waves of the less refrangible extremity of the spectrum, while the terminal apparatus of the nerves adapted for green and violet are very feebly stimulated, and the sensation of red is the result. In like manner, when the sensation of green is perceived, the terminal apparatus of the nerves adapted for conducting the impression of green are stimulated by the waves of moderate amplitude in the middle of the spectrum, while the red and violet fibers respond but slightly to such waves, and the sensation of green results. And so, too, the fibers adapted for conducting violet respond to the short and rapid waves of the more refrangible rays which have only moderate action on the green, and still less on the red conducting fibers. The intermediate colors, such as orange, are due to the simultaneous stimulation of the several sets of fibers to a greater or less extent, and when all these sets are equally excited the impression of white light results.

Lately, a new theory—that of Hering—has been advanced. According to this physicist there are six simple sensations of vision, and the various colors seen result from their different association and blending. These elementary sensations are disposed in couples or antagonistic pairs; black and white, green and red, yellow and blue. On this theory violet is a compound color formed by the blending of blue and red, and in an ordinary perception of color four primary sensations are excited; black and white, and two colors; but the blue and the yellow are never simultaneously excited, nor are the red and the green. When the blue sensation is experienced the yellow is virtual, and, though present, is not perceived by the mind. Black and white are capable of mingling, and produce all the shades of gray, but red and green, or blue and yellow, have no disposition to blend, but rather behave like the poles of an electric battery, and it is in this sense that the school of Hering, of which Happe is the chief exponent, speak of the polarity of colors. The organic substratum of color sensation, according to Hering, is not the terminal apparatus of the nerve fiber itself, but certain hypothetical substances, such as the visual purple, which undergo chemical change. On looking at "white" light, the visual purple, by a photochemical process, is constantly undergoing decomposition and destruction, and is as rapidly restored. Red light decomposes the visual purple slowly, violet light decomposes it more rapidly. Further, on Hering's theory, processes both of disassimilation and of assimilation are supposed to take place, so that when exposure to red light has exhausted or partially destroyed the visual purple, or its mother substance, purpurogene, green light aids in the reparation of this material, and fits the eye again for perceiving red light. Black does the same office for a retina exhausted with white light, and blue for yellow. This theory affords a good explanation of the phenomena of contrast, and of complementary colors. A red wafer placed on a sheet of white paper gives the sensation of a vivid red disk. As long as it is looked at it causes disassimilation of the retinal purple, which is as constantly renewed; but if the eyes be closed, the sensation of red vanishes, and is replaced by green. Why? Because assimilation is now taking place in excess of disassimilation. When one of these states is equal to the other two, the two antagonistic sensations are reciprocally destructive. Hence red and green do not blend to form white. The third theory, originally suggested by Draper, and more recently developed by Preyer and by Charpentier, refers the color sensations we perceive to modifications of temperature. Preyer distinguishes the quantity or intensity, the quality or tone, and the temperature. The intensity depends on the force with which the retina is impressed by the ethereal waves; the quality on the nature of the excitation caused by the vibrations of the particles of ether constituting the waves, vibrations the rapidity of which increases with the diminution in the size of the waves. In regard to temperature, Preyer differentiates the colors into hot and cold—the warm colors are red, orange, yellow, and yellow-green; the cool colors are green-blue, blue, and violet. Charpentier, who has just completed a series of researches with Landolt, finds that the statements recently made to the effect that certain zones of the retina are specially adapted for the perception of certain colors have been founded on imperfect observations, and that even the most peripheral portions of the retina can differentiate colors providing they are sufficiently intense. Aware of the observations of Munk and Samelsohn, the former of whom seems to have demonstrated that the seat of chromatic sensation is in the cortical layers of the occipital lobes, while the latter has published a case of hemianopsia, in which the sense of space was preserved in the affected half of the retina while the chromatic sense was lost, Charpentier differentiates in every normal eye a sensibility for light, a sensibility for color, and a visual sensibility or sensibility for form. In every chromatic impression made on the peripheric regions of the retina he further distinguishes three phases: a simple impression of light, a vague indeterminate impression of color, and a distinct impression of the true color. The first phase he thinks clearly proves that the luminous sensation is distinct from that of color, that it is the result of a simple excitation of the optic nerve, but in the second phase the cerebral centers for color are excited, and the reason that a quicker and surer recognition of color is made by the macula and central parts of the retina is only because they are more used. The sense of color and of light being a general function of the retina, he regards neither the rods nor the cones as the retinal elements which are stimulated by chromatic stimuli. He rather looks to the layer of ganglionic cells which lie on the anterior part of the retina as the functionally active elements. It is clear that there is still a wide field for research in this subject open to the scientific explorer.—*Lancet.*

MALTOSE.

THIS sugar has been very fully investigated since O'Sullivan first defined its principal chemical and physical properties, but unfortunately the results obtained differ much from each other. The latest experiments in this direction are by E. Meissl, whose researches are published in the German *Journal of Practical Chemistry*. On making experiments with various preparations of maltose and using a sodium flame, the author found that its specific rotatory power varies inversely with the temperature and concentration. As a mean of several experiments he gives the following equation for the specific rotatory power of maltose with the sodium flame: $[\alpha]\ D = 140·375 - 0·01887\ P - 0·095\ T$, where T represents the temperature and P the percentage of maltose in the aqueous solution. As previously shown, maltose possesses birotatory powers, 15° to 20° difference being observable between freshly prepared and stale or heated solutions, and for solutions lying between 5 to 40 per cent. The percentage of maltose may be accurately found by multiplying by the factor 0·362 the degree of rotation obtained at 17·5°, a tube 200 mm. (nearly 8 in.) long being employed. The assimilation of the elements of water to maltose is attended with much greater difficulty than in the case of cane-sugar, and its conversion into dextrose is best attained by three hours' heating with a 3 per cent. solution of sulphuric acid. Under the most favorable conditions, however, only 98·5 per cent. of the maltose can be converted into dextrose, as a point is arrived at where the destruction of the ready formed dextrose proceeds with greater rapidity than the formation of fresh dextrose.

A SIMPLE METHOD OF RECOVERING THE SILVER FROM WASHED EMULSION.

AN easy, efficient, and, at the same time, inexpensive method of recovering the precious metal from washed emulsion is a great desideratum—alike to the manufacturer of gelatine plates on a commercial scale and to the amateur, who may possibly have but, comparatively, a few ounces of silver in the accumulated residues of many months' working, yet too large a quantity to sacrifice if it could be easily recovered. Of course, if the water in the emulsion be evaporated, the gelatine can be burnt away in a crucible, leaving an ash and the bromide behind, to be afterward dealt with in the furnace like ordinary residues.

Those who have adopted this course know full well the difficulty there is of getting rid of the gelatine by this means; for, unlike the cuttings of paper, it will not burn of itself, and, when heat is applied to assist the combustion, the gelatine frizzles up and expands, then chars, but is not consumed unless a very strong heat be used, and then only after a somewhat long application. Moreover, the fumes given off are by no means pleasant. Even after the gelatine has been so far destroyed a bulky ash always remains, which takes up considerable room in the crucible, and thereby increases the cost of reducing by necessitating a longer time in the fire, and consequently entailing the consumption of more fuel, as well as requiring a larger proportion of flux.

To obviate this difficulty, various methods have at times been suggested. Captain Abney recommends two plans—one being to boil the emulsion with caustic potash, and the other to boil it with hydrochloric acid. By each of these methods the setting property of the gelatine is destroyed, and the silver subsides. These plans answer the purpose admirably, but many complain of the trouble of the boiling operation when large bulks have to be treated, as in the case of the residues accumulated in manufactories where a large business is conducted.

Another plan suggested is that of mixing sawdust with the waste, and then drying and burning it. By this means the gelatine is more completely consumed than when it is burnt by itself; but in this case there is a large amount of ash produced, which is a disadvantage. In order to overcome this, and to obtain the ash as "concentrated" as possible, after the sawdust is dried it is mixed with more emulsion and again dried. After saturating and drying several times, the mixture is finally wetted with a strong solution of nitrate of potash, and dried again. It will then burn with great energy, evolving sufficient heat in some instances to reduce part of the silver to the metallic state, the carbonate of potash formed by the combustion of the nitrate acting as a flux. This plan, although very efficient, has the disadvantage of involving a great deal of trouble.

About twelve months since, M. Ferdinand Braun, of Dornach, gave, in our columns, his method, which is to precipitate the gelatine with tannic acid, and this, as it subsides, carries down the bromide with it. The precipitate is then dried and burnt in a crucible, and afterward reduced by the refiner. In a recent number of the *Correspondens* Dr. Schleussner advises a modification of M. Braun's method, by employing a mixture of gallic and tannic acids dissolved in alcohol as a precipitant, and then to add sawdust to the precipitated gelatine and bromide before burning. By each of these plans also we have the ashes from the sawdust, as the charred gelatine, to deal with, which, of course, increases the bulk to some extent, while, moreover, the plan is somewhat costly. It is manifest that any method like that of Captain Abney (by which the bromide is separated from the gelatine) will be a considerable advantage in practice. This, it is true, may be accomplished by the employment of Mr. Plener's apparatus, but few are yet provided with that.

In a recent conversation, Mr. E. W. Foxlee mentioned to us a very simple plan by which he had recovered the silver from a large quantity of emulsion residues by first separating the bromide. It was simply to dissolve the emulsion and then add a considerable quantity of the waste acids from the manufacture of pyroxyline. By this means the gelatine was decomposed, and the pure bromide then subsided in an hour or two, when the fluid portion could be decanted perfectly free from silver. After washing, to free it from acid, the bromide was dried and fused with the carbonate of potash and soda in the ordinary manner. This plan appeared to us so simple and inexpensive that we determined to try some experiments with it ourselves, the result of which we now give for the benefit of our readers.

We took some old emulsion, and, after melting it, poured in some mixed acids that had been used for pyroxyline-making some years ago, and had been reserved for cleansing dirty bottles, dishes, and the like. A somewhat violent action ensued after the addition, red fumes being given off for a short time. In about an hour the bromide had subsided to the bottom of the vessel, and the supernatant liquor could be poured off, which, on testing, was found to be perfectly free from silver. As the waste acids from the manufacture of pyroxyline are not at the command of every one, and to prepare them specially would make the process rather more costly, we determined to try the effect of sulphuric acid alone, using the common kind usually retailed at about twopence per pound. We took six ounces of waste emulsion, which had been prepared at different times when experimenting, and added to it three fluid ounces of the acid, and after well stirring, the jar was filled up with hot water. In an hour the bromide had all subsided in a compact mass at the bottom. The fluid portion was then poured off and tested, but no silver was present. The emulsion we employed in this experiment was somewhat decomposed and had become rather thin; so, to put the method to a crucial test, we took six ounces more of the emulsion and added to it half an ounce of Coignet's "gold medal" gelatine. This made it somewhat thicker than ordinary emulsion. Three ounces of sulphuric acid were then stirred in and the jar filled up with hot water as before; but the bromide subsided as quickly as it had done in the previous experiment. From the manner in which the silver went down in these experiments, we have little doubt that less acid would suffice; but we had no opportunity of determining this, as we had already exhausted our stock of waste emulsion. When the bromide is obtained in an isolated state the silver may be recovered from it in precisely the same way as from the chloride.—*Br. Jour. of Phot.*

NEW PLASTIC COMPOUND.

By EDWARD WESTON, of Newark, N. J.

THE new product which forms the subject of my invention is a tough, flexible, and homogeneous substance exhibiting many of the physical characteristics of ordinary celluloid, but differing therefrom with respect to its chemical composition, and to qualities that render it non-explosive and even less inflammable than cellulose as ordinarily obtained. It is, in fact, cellulose so far as its chemical composition is concerned, but cellulose without fibrous or other definite structure. When properly prepared it is transparent or translucent, and in this condition it is capable of a great number of uses, both as a substitute for celluloid, and also for special purposes, to which the latter is not applicable.

Cellulose in the form in which I have described it may be prepared from cellulose as it ordinarily appears—that is to say, as cotton, cotton waste, linen, or paper—the complete process being substantially as follows: A quantity of any of the above mentioned materials—viz., cotton, linen, or paper—is immersed in a mixture of sulphuric and nitric acids, as in the usual preparation of pyroxyline, nitro-cellulose, or gun-cotton. The action of this mixture should be continued for twenty minutes, more or less, at the end of which time the cellulose has undergone a chemical change, becoming pyroxyline, its fibrous condition still remaining.

From the condition of pyroxyline, it is best converted into collodion or celluloid, according to the solvents employed. If, for instance, the pyroxyline, after being properly washed and dried, be dissolved by a mixture of ether and alcohol, the product usually termed "collodion" is produced. If, on the other hand, the pyroxyline be dissolved with naphtha, nitro-benzol, or camphor alone, or with other solvents, the resulting product is known commercially as "celluloid." Both of these substances and the processes of manufacturing them are well known, and a more detailed account of their production is therefore unnecessary. It is, however, to be observed that neither exhibits any definite structural characteristics, being practically homogeneous or amorphous, that their fluid or plastic condition renders them capable of being formed in sheets or other forms, and that both are highly inflammable and burn without leaving appreciable residues. From these substances I produce chemically pure cellulose in an amorphous condition by treating them with suitable reducing agents, which, for convenience, I term "deoxidizing agents," the effect of such treatment being to deprive the collodion or the celluloid of their vitreous properties and bring them back to their original chemical condition as cellulose. This treatment consists in immersing the sheets or other forms of collodion or celluloid in a bath of ammonium sulphide, protochloride of iron, sulphate of iron, or other chemically-equivalent agents that effect the necessary reactions, allowing them to remain in the bath until the mass of collodion or celluloid has been entirely reconverted or deoxidized. The resulting product is then to be washed and dried, after which it is in condition for use.

It will thus be seen that, apart from the well-known steps necessary to the production of collodion or celluloid which have been specified, my process consists in treating either pure collodion, celluloid, or any other body that is pyroxyline without fiber by reducing agents that will reconvert them to the chemical condition of cellulose.

The article, when thus produced, being extremely dense, tenacious, and flexible, is applicable to the manufacture of belting and many other useful purposes. From its transparent qualities it may be used as a substitute for glass or mica in places where it is not likely to be exposed to abnormally high temperatures. As a substance from which to prepare the carbons of electric lamps it is particularly well adapted, owing to certain remarkable qualities in the carbon which it produces. I would, however, state that its use in this connection is not specifically claimed herein, as the same is made the subject of another application of even date herewith.

I desire, further, to state that the process of manufacture above described may be varied in some respects, which are clearly within the scope of the invention as disclosed.

I do not, for instance, restrict myself to the specific manner of treating the collodion or celluloid with the reducing agents—in other words, to the manner of applying these agents to the said substances for the removal of their vitreous principles.

In preparing articles of pure amorphous cellulose it is not essential that the cellulose be first produced and the articles then cut or shaped therefrom, as it is evident that the articles—such, for instance, as the blanks for incandescent carbon conductors—may be formed directly from the collodion or celluloid, and then immersed in one of the solutions named.

I am aware that heretofore soluble nitro-cellulose has been treated with ammoniacal salts for the purpose of rendering the same less explosive or inflammable. To this method or process, or to the product resulting therefrom, I do not lay claim.

DESTROYING INSECTS UNDER GLASS.

THE following method, says the *Revue Horticole*, has given most satisfactory results, and the inventor, M. Boizard, gardener to Baron Rothschild, at Paris, assures us that success is infallible—at least for three years during which he has been experimenting with it it has been so with him. He says: "Having procured two quarts of tobacco juice, I boil it over a slow fire on a furnace in the house. An hour and a half or two hours afterward, the liquid being reduced to about one-third its bulk, becomes viscid and almost solid, when, after having diluted it into one quart or 1¼ quarts of water, I boil it more quickly until all get converted into vapor and fixed in the form of dew on every portion of the plants. I remarked no damage done, not even among the most tender plants, such as Adiantums, young plants of Blechnum braziliense, Coleus, etc. Some young fronds of Adiantum alone suffered, but it should be added that they were on the stages." If danger were apprehended in the case of certain plants, they might be taken out or their safety assured by means of paper caps; and if it was a question of flowers or fruits, similar precautions might be taken to preserve them. M. Boizard assures us that no insects can resist this treatment, and that a greater portion of them do not appear again for six months. In the case of such as reappear quickly, it is easy to renew the operation, but then one quart of tobacco juice and one quart water will suffice. This method is as economical as any other, and M. Boizard says that it is possible to remain in the house during the operation without being inconvenienced thereby.

A FEW NOTES ON THE LARVAL STATE OF THE PEA-WEEVIL.

(*Sitones Lineatus*, Linn.)

By THOMAS H. HART.

FROM the time I began the study of entomology, the mystery attaching to the early stages of the pea-weevil has always been a source of attraction to me. Nor have there been wanting circumstances to keep it fresh in my mind. At one time my beans, at another my peas, have been attacked by it to my cost, and I have also attributed to a *Sitones* much of the damage done to my clover in some seasons; but all my efforts to discover the egg or larva were futile. Plants by the dozen were drawn from the infested crops and critically examined, as were innumerable growing plants, but neither leaf, stem, nor root disclosed anything. The old story was repeated last spring. *Sitones* threatened the complete destruction of six acres of gray peas. All the means at our disposal were unavailing to check its ravages, and but for a timely shower to reinvigorate the plants the crop must have been lost. Here, again, all my endeavors to detect the egg or larva were to no purpose, until one morning a letter arrived containing a reference to a clover root-feeding larva. This set me pondering once more, and in the evening I wandered aimlessly into the pea field, my brain busy with *Sitones*. I went to work, and the result was that before I left I had discovered a small white grub feeding at the root of the peas, which on examination proved to be curculionideus. Elate with my success, I sought and procured more of the grubs, dispatched specimens to the care of others interested in the subject, and placed a few in security for my own observation. This was on the 31st of May, and on the 4th of July I had the gratification of seeing the first perfect *Sitones lineatus* in the box where I had placed the pupæ. Thus, by digging up the plants bodily and carefully removing the earth from the roots, was the problem solved, whereas in all previous attempts I had drawn the plants after loosening the soil, and consequently had left behind that of which I was in search. Evidently John Curtis was very near the mark when he examined the bean roots for galls, as mentioned in "Farm Insects," p. 345; but probably it was too early in the year. Had he repeated his search at intervals throughout the season, there is now little doubt that he would have laid the matter bare some forty years ago.

Contrary to the usual order of things, the pea-weevil does comparatively little mischief in the larval state. True there were indications of the grubs having eaten channels along the main root, but the peculiar gall-like growths on the fibers appear to be their favorite food. It is just possible that they may have to do with certain portions of a crop dying away

SITONES LINEATUS.

prematurely in dry seasons by destroying the fibers or causing excrescences to grow on them, and thus diverting the flow of sap from its proper course; but with sufficient moisture, fair tilth and cultivation, there is reason to believe that the plant will arrive at maturity notwithstanding the grubs. The fact that several of the larvæ had ensconced themselves within the above-mentioned galls, made me suspect their formation was due to the insect, but I could find nothing in those without a visible entrance to confirm my suspicion.

In its perfect state, however, the weevil more than compensates for the apparent harmlessness of the larva; its depredations are little noticed till the following spring, but no sooner do the peas and beans show above ground than we are painfully reminded of their presence. A succession of wet days, or prevalence of east wind, or other cause to check the plant, and the havoc committed in a short space of time is heartrending to witness. The leaves are scalloped round the edge into fantastic forms, the younger ones often being eaten to the midrib; the stems turn yellow; what remains of the leaves assumes a purplish tint, and, if the weather still continues unfavorable, the crop is lost. Yet the cause of all this mischief is invisible to the ordinary observer. The habit of the insect is to fold its legs and fall at the least alarm, and remain hidden among the clods during the day, coming out to feed at night. Should the soil in which it is secreted be disturbed it will roll about among the clods without giving any sign whatever of life; but press the ground for some half yard square firmly with the foot, go down on one knee, remain motionless, and in a few seconds the place will appear alive from the innumerable weevils that will push their way through to the surface. This gives us a clew to the remedy. If the weather admits of the free and repeated use of the roller, a great proportion of the beetles will be crushed or smothered by preventing them coming to the surface for air, and the plants—freed in a measure from their constant gnawing, and being assisted shortly afterward by the hoe—will make new and vigorous growth, and soon bid defiance to what are left of the insatiable little beings.

It would appear that the eggs are deposited beneath the surface of the ground at the time the beetles are devouring the plants, but in what manner still remains to be cleared up.

Appended is a short description of the different stages of the weevil in question:

The maggot-like larva is white, plump, and wrinkled, with brown horny head, and a pair of powerful projecting jaws. Each segment bears a few short hairs. Legs none; anal segment used as a foot. When full fed it forms an oval cell without lining, about two inches underground, and at once undergoes transformation.

The pupa is also white, but as it matures the eyes become black and the rostrum pitchy; rostrum bent down on to breast; legs folded under thorax; wings and elytra brought round so as to cover posterior pair of legs, not sealed down; each segment with a row of spurs, and anal one with a pair of long spines at apex.

The imago is at first creamy white, with head pitchy and eyes black, soon, however, becoming entirely black (with exception of part of legs and antennæ, which are red), and clothed with silver-gray scales, three stripes along the thorax being of lighter shade than the rest. Specimens confined in a box attained their normal color in about forty-eight hours, but at large the beetles do not appear to leave their nidus for some time longer, probably to admit of their integuments becoming fully hardened before exposure.

Park Farm, Kingsnorth, Ashford, Kent, July 21, 1882.

Note.—With regard to the deposit of eggs, I am able to state that, somewhat earlier in the season than the date at which the larvæ of *S. lineatus* were observed by Mr. Hart among the pea roots, I have found that weevils taken from off the peas paired and laid eggs profusely in captivity. These small white eggs were laid indiscriminately on the glass and cork of the cage, or on any surface, there being no depth of earth wherein to bury themselves for oviposition, and all the eggs perished; but looking at the circumstance of the egg laying just preceding the time of the larvæ being found, and connecting this with the known habit of the pea-weevil burying itself in the earth, there seems to me, though we have no direct record as yet on the subject, to be little doubt that in April or May the females go down to oviposit a little below the surface of the ground among the pea roots. —*E. A. Ormerod, in the Entomologist.*

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